

Critical Thinking Levels on Acid-Base Topic of 11th Grade Students in Yogyakarta

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Abstract. This study aims to determine the quality of critical thinking questions that are developed based on the review conducted by material experts, evaluation experts, and education experts, and determine the level of ability of critical thinking in the acid-base material on 11th grade students. This study included an ex-post facto study designed with a sample design that was applied to high 11th grade students in Yogyakarta City, which consisted of six Public and six Private High Schools. The level of critical thinking ability is measured by using 15 items. Before being applied to the sample, the questions were validated by three reviewers, included material experts, evaluation experts, and education experts. The results revealed that the quality of critical thinking developed based on the review were considered good and worthy of being used as a research instrument to test students' critical thinking skills, but with little improvement. The level of critical thinking skills in acid-base material is 40.2% (moderate / sufficient), six Private High Schools are 34.8% (less good), and a combination of both (Public High School and Private High School) of 37.5% (not good).

1. Introduction

In the current era of globalization, teachers are highly demanded to be able to promote students' thinking abilities not only at a low cognitive level, but at a higher level so that the students are accustomed to think critically, creatively, innovatively, and also eager to meet challenges. However in the real world, only few teachers are willing to give thought-provoking questions to their students in the learning process.

Teachers should ask more divergent questions to accustom the students to use their logic and reason. The questions "why, how, and explain" should be raised more than convergent questions that only ask for short and simple answers, and less involving mental process (reasoning), because teachers only ask "what, who, when, and where".

The results of TIMSS and PISA show that our students are highly skilled in answering theoretical memorizing questions, but fail to solve questions with high-level aspects, namely questions that require applying and reasoning [1]. This fact shows that the learning process in Indonesia is relatively incapable to encourage the students to use the concepts that they have learnt as the background for logic and reason to solve problems. Therefore, in the Curriculum 2013, the teachers are expected to be able to create challenging learning, so as to be able to evoke students' critic, logic, creative, and innovative. The students' creativity can be cultivated if the teacher does not dominate the learning communication process, but rather inspires them to flourish [2].

One of the thinking skills that must be cultivated nowadays is the critical thinking. Critical thinking is a discipline process that is intellectually active and skilled at conceptualizing, implementing, analyzing, synthesizing, and / or evaluating information collected from various processes [3]. Through critical thinking, a person is able to perceive things more accurately, select information more objectively, consider problems as challenges to solve, and have a high curiosity on something with indefinite answer.

Thus if students have the ability to think critically, then all information about the learned material will be appealing, because the curiosity to study deeply always aroused. Critical thinking ability is the ability to analyze an argument, bring insight into each meaning and interpretation to develop logical and cohesive patterns of reasoning, be able to understand assumptions and biases that underlie each position, so students can provide a reliable, light and convincing presentation model [3].

Critical thinking is the ability to analyze the existing facts, then formulate several ideas, defend those ideas, and make comparisons. By making comparisons, students can draw conclusions and make solutions to the existing problems [4]. Critical thinking does not only occur in the scientific world but also in everyday experience. Cultivating a critical attitude is actually intended to encourage students to think clearly [5]. Besides, critical thinking can assist students to have appropriate and deep knowledge and understanding.

According to [6], the ability to think critically is the ability of individual to use their thought processes to analyze arguments and provide interpretations based on appropriate and rational perceptions, assumptions analysis of logical arguments and interpretations. The critical thinking ability is the skill of someone who in his process of thinking is able to analyze something and capable to convey it verbally or in writing logically and rationally.

Students are sometimes confronted with problems that present random data and limited information, but actually the random and limited data contain information that can be disclosed if they really think critically. By thinking critically students can find various ways to solve problems [7]. Consequently, the learning process that involves students in problem solving becomes very substantial to be applied. This is because basically the ultimate goal of learning is to generate students with the knowledge and skills in solving problems to be applied later in the community or the workforce. Considering the various types of problems discussed in the learning process, therefore there are many also the problem solving strategies.

Science always contends with scientific truths in the form of theses and hypotheses, which will be the basis of presuppositions. These truths can only be examined continuously through critical thinking. To be able to examine properly to achieve the true truth, critical thinking activities must be encouraged. The characteristics of critical thinking ability are the ability to[8]:

1. distinguish facts, non-facts and opinions;
2. distinguish definitive and tentative conclusions;
3. test the level of trust;
4. distinguish relevant and irrelevant information;
5. make a decision;
6. identify cause and effect; and
7. consider other insights.

Based on the descriptions, this study aims to determine empirically the quality of critical thinking questions developed based on the results of the reviews conducted by three reviewers of material experts, evaluation experts, and education experts. Besides, this study also determine the level of critical thinking skills on the acid-base material of 11th grade students from six public high schools, six private high schools, and a combination of both (public and private high schools) in the city of Yogyakarta in the 2018/2019 academic year based on the pattern of students' answers to the questions of critical thinking developed.

2. Research Methods

This research is an ex-post facto study that was designed with a single sample design which was imposed on grade XI of high school students in Yogyakarta City in the academic year of 2018/2019. The study involves six public high schools, namely sample 1, sample 2, sample 3, sample 4, sample 5, sample 6 and six Private High Schools, which include sample 7, sample 8, sample 9, sample 10, sample 11, and sample 12 SMA BOPKRI 1, and SMA BOPKRI 2, each of which was taken two classes.

The level of critical thinking ability is measured using 15 items of critical thinking questions outlined from 7 criteria of critical thinking which includes the ability (1) to distinguish facts, non-facts, and opinions, (2) to distinguish definitive and tentative conclusions, (3) to examine the level of trust, (4) to distinguish relevant and irrelevant information, (5) to make decisions, (6) to identify cause and effect, and (7) to consider other insights [8].

Prior to be presented to the sample, the questions were validated theoretically. The questions were reviewed by the three reviewers. The three experts are material experts (Dr. Isana Supiah YL, lecturer at the Department of Chemistry, FMIPA UNY), evaluation expert (Dr. Sri Yamtinah, lecturer at the Department of Chemistry, FKIP UNS), and education expert (Dr. Maria Paristiwati, lecturer of the Department of Education Chemistry FMIPA UNJ). From the obtained data, the number of the correct answers for each item was calculated as well as for the items that represent a criterion from a high school, overall public or private high schools, and a total percentage of the 12 high schools sampled. The percentage obtained is then converted to a category range from very poor to very good.

3. Results and Discussion

The pattern of the students' answers from each high school were recorded in the provided basic data, in order to obtain the recapitulation of the average percentage per criterion as well as the overall percentage of criteria for each high school that is sampled. The summary of the recapitulation results for Public high Schools are presented in Table 1.

Table 1. The average percentage of each criterion for Public high School

No.	School Name	Class	% Average Per Criterion*)							% Average All Criteria
			1	2	3	4	5	6	7	
1.	Sample 1	IPA-5	54.2	45.3	29.7	37.5	34.4	29.7	45.3	40.6
		IPA-6	46.7	35.0	25.0	38.3	36.7	28.3	31.7	35.3
		% Average	50.5	40.2	27.4	37.9	35.6	29.0	38.5	38.0
2.	Sample 2	IPA-1	43.8	28.1	42.2	48.4	39.1	40.6	46.9	41.5
		IPA-5	49.0	45.3	43.8	40.6	43.8	51.6	32.8	44.2
		% Average	46.4	59.4	43.0	44.5	41.5	46.1	39.9	42.9
3.	Sample 3	IPA-2	54.0	39.7	41.4	27.6	36.2	37.9	34.5	39.8
		IPA-3	57.5	39.7	53.4	39.7	41.4	17.2	29.3	40.9
		% Average	55.8	39.7	47.4	33.7	38.8	27.6	31.9	40.4
4.	Sample 4	IPA-5	52.1	59.4	39.1	39.1	20.3	34.4	26.6	39.6
		IPA-6	45.8	39.6	35.4	29.2	33.3	41.7	35.4	37.8
		% Average	48.9	49.5	37.3	34.2	26.8	38.1	31.0	38.7
5.	Sample 5	IPA-2	24.2	40.9	11.4	50.0	52.3	50.0	27.3	35.8
		IPA-6	28.4	29.4	39.7	20.6	39.7	44.1	25.0	32.2
		% Average	26.3	35.2	25.6	35.3	46.0	47.1	26.2	34.0
6.	Sample 6	IPA-4	47.0	59.1	59.1	54.5	36.4	52.3	36.4	49.1
		IPA-5	52.4	42.9	33.3	59.5	33.3	35.7	54.8	45.1
		% Average	49.7	51.0	46.2	57.0	34.9	44.0	45.6	47.1
% Average per Criterion for All Schools			38.2	45.8	37.8	40.4	37.3	38.7	35.5	
% Average All Criteria (6 Schools)										40.2

Information:

- Criterion 1 = The ability to distinguish facts, non-facts, opinions
- Criterion 2 = The ability to distinguish definitive and tentative conclusion
- Criterion 3 = The ability to test the level of trust
- Criterion 4 = The ability to distinguish relevant and irrelevant information
- Criterion 5 = The ability to make decision
- Criterion 6 = The ability to identify cause and effect
- Criterion 7 = The ability to consider other insight

Table 1 presents that sample 6 has the highest overall average that is 47.1% , while the lowest overall average is acquired by sample 5 with 34.0%.The summary of the recapitulation result for private high school is presented in Table 2.

Table 2. The Average Percentage for each criterion for Private High School

No.	School Name	Class	% Average per Criterion*)							% Average All Criteria	
			1	2	3	4	5	6	7		
1.	Sample 7	IPA-1	32.3	34.4	28,1	31.3	53.1	34.4	26.6	34.2	
		IPA-2	25.5	29.4	26.5	42.6	50.0	22.1	35.3	32.5	
		% Average	28.9	31.9	27.3	37.0	51.6	28.3	31.0	33.4	
2.	Sample 8	IPA- 4	41.4	32.8	19.0	29.3	31.0	22.4	32.8	30.6	
		IPA-5	38.5	34.4	18.8	32.8	35.9	34.4	18.8	31.0	
		% Average	40.0	33.6	18.9	31.1	33.5	28.4	25.8	30.8	
3.	Sample 9	MIPA-1	46.2	30.6	30.6	17.7	43.5	21.0	50.0	35.1	
		MIPA-2	46.4	44.6	26.8	28.6	39.3	30.4	39.3	37.1	
		% Average	46.3	37.6	28.7	23.2	41.4	25.7	44.7	36.1	
4.	Sample 10	MIPA-1	48.1	9.7	56.9	51.4	29.2	52.8	47.2	42.6	
		MIPA-2	53.8	29.5	37.2	21.8	37.2	46.2	43.6	39.5	
		% Average	51.0	19.6	47.1	36.6	33.2	49.5	45.4	41.1	
5.	Sample 11	MIPA-2	18.5	53.7	20.4	25.9	38.9	24.1	42.6	31.1	
		MIPA-3	17.2	41.4	17.2	19.0	29.3	31.0	24.1	25.1	
		% Average	17.9	47.6	18.8	22.5	34.1	27.6	33.4	28.1	
6.	Sample 12	MIPA-1	26.3	15.8	57.9	39.5	68.4	57.9	26.3	40.7	
		MIPA-2	40.4	73.7	57.9	25.0	51.3	39.5	23.7	39.0	
		% Average	33.4	44.8	57.9	10.5	34.2	21.1	21.1	37.2	
% Average per Criterion for All School			36.3	35.9	33.1	29.3	30.4	33.2	34.0		
% Average All Criteria (6 Schools)									34.8		

Table 2 shows that Sample 10 has the highest overall percentage by 41.1%, while the lowest overall percentage is obtained by Sample 11with 28.1%. Both results of the recapitulation of the average percentage of each criterion for Public High Schools and Private High Schools are then calculated for each criterion and the overall criteria from a combination of six Public High Schools and six Private High Schools. The results of the calculations are presented in Table 3. Table 3 shows that criteria 1, 3to 7 are in the unfavorable category, and only criterion 2 is in the moderate / sufficient category. The percentage of overall criteria is in the unfavorable category, which is 37.5%.

Table 3. The Average Percentage per Criterion for All (Combination of Public high School and Private High School)

No.	School Status	Σ Class	% Average per Criterion							% Average All Criteria
			1	2	3	4	5	6	7	
1.	Public	12	38.2	45.8	37.8	40.4	37.3	38.7	35.5	40.2
2.	Private	12	36.3	35.9	33.1	29.3	30.4	33.2	34.0	34.8
% Average per Criterion (12 Schools)			37.25	40.85	35.45	34.85	33.85	35.95	34.5	
% Average All Criteria (12 Schools)										37.5

The students' score is converted to a value to obtain the average poin of each class, each high school, all public high school (6 high schools), all private high school (6 high schools) and the average value of all high school sampled (12 highschoools) are obtained. The result of the recapitulation is presented in Table 4.

Table 4. The Data Recapitulation of the Average Result of Critical Thinking Ability Test

No.	Public high School	Class	Average Value (%)	Total Average	No.	Private High School	Class	Average Value (%)	Total Average
1.	Sample 1	MIPA 1	41.5	47.55	7.	Sample 7	IPA 1	34.2	33.40
		MIPA 5	53.6				IPA 2	32.6	
2.	Sample 2	IPA 5	40.5	37.90	8.	Sample 8	IPA 4	30.6	30.85
		IPA 6	35.3				IPA 5	31.1	
3.	Sample 3	IPA 2	39.8	40.40	9.	Sample 9	MIPA 1	35.1	36.10
		IPA 3	41.0				MIPA 2	37.1	
4.	Sample 4	MIPA 5	39.5	38.65	10.	Sample 10	MIPA 1	42.5	40.95
		MIPA 6	37.8				MIPA 2	39.4	
5.	Sample 5	MIPA 2	35.8	33.95	11.	Sample 11	MIPA 2	31.1	28.05
		MIPA 6	32.1				MIPA 3	25.0	
6.	Sample 6	MIPA 4	49.1	47.0	12.	Sample 12	MIPA 1	40.7	39.00
		MIPA 5	45.1				MIPA 2	37.3	
Total			245.55		Total			208.5	
Average Value of 6 Public high School				40.93	Average Value of 6 Private High School				34.73
Overall Average (12 Schools)					37.83				

The table 4 shows that the lowest average value for Public high school is achieved by Sample 5 with 33.95%, while the highest average value is obtained by Sample 1 with 47.55%. The lowest average

value for Private Highschool is achieved by Sample 12, which is 28.05%, while the highest average score is achieved by Sample 10, which is 40.95%. The average value of all Public high schools (6 High schools) shows a higher average (40.93%), compared to the average value of all Private High schools (34.73%), or a discrepancy of 6.2%. The average overall value of the sampled high schools (12 high schools) showed a relatively low result, which is 37.83%.

The recapitulation shows that for each tested criterion, the largest percentage of those who answered correctly were not always achieved by students from the same high school, both public and private high schools. For example, the criterion 1, namely the ability to distinguish facts, non-facts, and opinions represented by questions number 1, 2, and 3, the largest percentage for public high schools is achieved by Sample 3, which is 55.8%, while Sample 3 has the lowest percentage in criterion 6, which is the ability to identify the causes and effects represented by questions number 12 and 13. Similarly for private high school, Sample 10 has the largest percentage in criterion 1, which is 51.0%. However, in criterion 2, namely the ability to distinguish definitive and tentative conclusions represented by questions number 4 and 5, Sample 10 has the lowest percentage, which is only 19.6%. This result also applies to other high schools, which means that students from one high school have critical thinking skills that stand out on one criterion, but at the same time have relatively low ability on other criteria.

Observed from the overall average of the seven criteria of critical thinking ability (see Table 3), the highest percentage of public high schools is achieved by Sample 6, which is 47.1% or in the moderate/sufficient category. On the contrary, the lowest percentage is achieved by Sample 5, which is 34.0% or in the unfavorable category.

Similarly for private high schools, the highest percentage is achieved by Sample 10, which is 41.1%, or in the moderate / sufficient category. On the contrary, the lowest percentage is achieved by Sample 11, which is 28.1% or in the unfavorable category.

The average percentage of all criteria for Public High Schools (40.2%) and Private High Schools (34.8%) shows a relatively moderate difference, namely 5.4% (see Table 3), with the overall average (12 High Schools) of 37.5%. When converted into qualitative criteria, the average for public high schools is in the moderate / sufficient categories, while for private high schools are in the poor category, and the overall average is in the unfavorable category.

The result shows that in both public and private high schools, which have been known as excellent high schools, apparently the students do not necessarily have the ability to think critically exceeding the high schools that have never been considered outclass. Although this critical thinking ability test is only limited to acid-base material, however it becomes empirical data illustrates that the students are still rarely accustomed to solve questions that reveal their critical thinking abilities, so that when confronted with this kind of problem they may not be ready to grasp the direction of the question. Therefore, the results of this study are expected to be input for the teachers to plan better learning, for example the teachers frequently associate the materials with the events or phenomena that occur in the students' surroundings, so that their ability to criticize is well improved.

This can be achieved if the teachers are enthusiastic to keep learning, extend their horizons, and improve their professionalism and self quality by providing innovations in learning, so that students are not only memorizing theoretical concepts, but are guided to the application of the concepts in life. The low learning results of the students in chemistry are probably caused by the process of learning in class which is focused only on theory, without being directed to associate the learning content with everyday life [9].

Thus, the subject matter delivered is useful for the students in life problemsolving, due to the provision of a deep concept related to the explanation of various natural phenomena that may occur in their lives. This is in line with the statement of [10] that students start learning chemistry with many expectations, one of which is expecting to understand the benefits of chemistry in everyday life [10]. Thinking critically will lead the students to find various ways of solving problems [7].

The scores obtained by students show that from both public and private high schools, the highest average score was achieved by Sample 1, which is 47.55%, while the lowest value was achieved by Sample 11, which is 28.05% (see Table 4). The interesting thing from the data of the average value is

that some of the public high schools in the sample turned out to have average value below the private high schools. For example, Sample 5, which has a mean value of 33.95, is below Sample 9 (36.10%), Sample 10 (40.95%), and Sample 12 (39.00%).

The results shows that critical thinking ability is not determined by the students' school, but it depends more on how the students are accustomed and trained to use their critical attitude in the learning situation. It is not impossible that the chemistry teachers in the private high schools is much more concerned with the students' questions that sometimes are rather strange, such questions that can only cross the minds of students with critical attitude.

According to Supardi (2015) if the value of the students is less than 60, then it is categorized as a failure, in the sense that the students do not have the ability to master the material in the problem. In this study, all the mean scores are below 60, it represents that the critical thinking ability of the students from the 12 high schools is still relatively low (unsuccessful), so it needs to be improved immediately [11]. This result is not the only indicator of the problem of the low ability of students' critical thinking, several other studies also indicate this condition. Some of the studies are the research of Lilis Wulandari, et al (2015) and the research of Inayah Adi Oktaviana, et al (2015). The results of both studies indicate that students' critical thinking skills are still low [12], [13]. This is partly due to the difficulties in understanding the concept, so that when the learning process takes place the students tend to be passive and are not enthusiastic to answer the questions given by the teacher [14]. Therefore, learning innovations to improve students' critical thinking skills is a need [15].

According to [15] critical thinking is a disciplined process that is intellectually active and skilled at conceptualizing, applying, analyzing, synthesizing, and or evaluating information gathered from various processes. One of the characteristics that students have a critical attitude is that when he gets information in the form of new concepts in the learning process, he quickly evaluates them in his cognitive structure, so that when ambiguity in the concept arises he will immediately ask questions.

With the questions posed, students' critical thinking will be directed in exploring the problems that demand immediate answers. In fact, there are still many teachers who do not like students who ask too many questions, whereas this type of student are actually expected to be in the classroom, so the class will be lively and the teacher's horizons are wide-spread. This condition will give impacts on other students to gain more knowledge than what is merely contained in books.

Fostering a critical attitude is actually intended to encourage the students to think clearly and explore a concept profoundly [5]. Furthermore, critical thinking will help students to get appropriate and deep knowledge and understanding. If the teacher delivers the subject matter less profoundly, then students ask questions, it is a sign that the student thinks critically, and the teacher must respond positively so that the critical attitude will nurture students, rather than dying slowly because the teacher does not respond to the question.

Many studies show that the students' critical thinking skills on chemistry subjects are still relatively low [12],[13]. It can be seen that when the learning process takes place, the students tend to be passive and the students' eagerness in criticizing the discussion is very low [13]. Therefore, the results of this study are expected to trigger the chemistry teachers in particular to improve the quality of the learning by designing learning in such a way that the students to critical thinking in learning.

This has been proven from the research of [16] that applied learning with a contextual approach before testing critical thinking skills, and the results showed a percentage of critical thinking skills of 64.5% or in the good category. Although these results are relatively unsatisfactory, but at least it shows that the application of contextual learning that is done by linking the material with phenomena and events in real life can improve the students' critical thinking skills.

The results of this study shows that high school chemistry teachers in particular should learn how to create learning that is able to familiarize and improve the critical thinking skills of their students. If delivering on their own is considered too difficult, the teachers can share with their colleague in the field of knowledge, both in the official forum (MGMP) and in small discussion forums through direct meetings and online (email, whatsapp, etc.). The teachers must understand that the era of globalization is full of challenges and competitions, consequently, the students in the future not only require

intellectual abilities to simple thinking, but the ability to think that enable them to cope with the challenges of their periods, such as critical, communicative, creative, and collaborative thinking skills [17].

The results of this study are expected to be followed up in the form of Community Service activities, especially the education community, namely high school chemistry teachers that are designed in the form of a workshop on the writing of problems with critical thinking skills for each subject matter contained in the chemistry subjects in high school, as well as, so the results of this study are of benefit in providing knowledge to the teachers in developing critical thinking skills. In addition, organizing seminars or workshops on the ways to create learning that can nurture the students' critical thinking skills can assist the teachers to apply it in the learning process in their respective schools.

4. Conclusions

Based on the results of the analysis and the discussion of this study, it can be concluded that: the quality of the critical thinking questions developed based on the results of a review conducted by three reviewers as material, evaluation, and education experts is considered good and appropriate to be used as research instruments to test students' critical thinking skills, but with a slight improvement. The level of critical thinking ability in the acid-base material of the students in grade XI in the city of Yogyakarta in the 2018/2019 academic year from six public high schools is at 40.2% (moderate / sufficient), six private high schools is at 34.8% (not good), and the combination of both (public and private high schools) is 37.5% (not good).

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