Problem-based learning model versus direct instruction in achieving critical thinking ability viewed from students' social attitude in learning physics

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Abstract

This study aims at analyzing the effect of problem based learning (PBL) compared to direct instruction (DI) on students critical thinking skills (CTA) viewed from their social attitudes (SA). This study used post-test only control group design. The population is 15 classes (584 students) of SMA 4 and SMA 6 Denpasar. The sample was chosen by random assignment technique and selected 4 classes (150 students = 25.7% of the population). The samples were divided into PBL group and DI group each 2 classes or 75 students. Furthermore, in each group sorted according to high and low SA, each of the 25 students (33%), both PBL and DI. Students CTA were measured by tests while SA are measured by questionnaires. Data were analyzed by 2x2 ANOVA. The results showed that students CTA in the PBL group higher than the DI group. Students who have high SA show higher CTA than those with low SA. PBL and DI models interact strongly with high SA in achieving CTA. The implication that guiding students to interact socially well is an alternative way for teachers so students can achieve adequate CTA in learning physics in SMA.

Keyword: Problem-based learning, social attitude, critical thinking ability

Introduction

The world of education in praxis cannot be separated from the learning process and student learning outcomes. The learning process is an indicator of student learning outcomes. Student learning outcomes are complex entities. Related to learning outcomes, the Council for the Advancement of Standards in Higher Education (CAS) (Komives, 2012) states that there are six domains of student learning outcomes that are expected as learning outcomes, namely (1) acquisition, construction, integration, and application of knowledge, (2) cognitive complexity, (3) intrapersonal development, (4) interpersonal competence, (5) humanitarianism and populist personal involvement, and (6) practical competence. Learning domains (1) and (2) involve the ability to think, while the other four domains involve social attitudes that are very much needed later when students are active in the workforce.

Learning to accommodate the six learning domains above should have become a vehicle for the development of learning skills for students in schools in accordance with the times. Students in schools have long entered the 21st century, which desperately needs specific learning skills. Learning skills needed in the 21st century include critical thinking skills, problem solving, creative thinking, communication, and collaborative skills (Partnership for 21st Century Learning, 2015). These abilities have indeed become a necessity along with the pace of the development of science and technology. The progress of science and technology requires someone to master information and knowledge.

Therefore, the ability to obtain, choose, and process information is needed. This ability requires critical, systematic, logical and creative thinking (Sirait et al., 2018). Therefore, a learning program is needed that can develop the ability to think critically, systematically, logically, and creatively.

Educational efforts in Indonesia to provide a vehicle for students to develop thinking skills above are still many obstacles. This cannot be separated from the education system in Indonesia which is still focused on the exam (Firdaus et al., 2015). Teaching practice focuses on lesson content and ignores the development of students' critical thinking skills (Rohaeti, 2010). The learning approach that is widely used in education tends to be direct learning (DI) (Santyasa et al., 2018). In DI, learning material is conveyed through face-to-face interactions between students and instructors, and the material is ordered in such a way and taught explicitly. Such learning methods have less optimal learning effects, especially in facilitating students to develop critical thinking skills (Santyasa et al., 2018). Another fact also states that direct learning produces a low impact on critical thinking skills, creative thinking skills, and collaborative skills among students (Winarno et al., 2018). Direct learning is not effective in learning physics (Jatmiko et al., 2018). Hammond et al (2015) refer to it as a conventional learning model. This model cannot facilitate developing students' critical thinking skills in learning physics, resulting in low learning achievement (Hammond et al., 2015).

The facts that the DI model is less accommodating for students in developing students' critical thinking, the DI model cannot be maintained in learning physics. One alternative as a substitute, is problem-based learning (PBL). The PBL model is one of the learning models that are in line with the times, including in learning Physics (Prayekti, 2016). PBL is one of the learning physics reforms that can create innovation in developing a new learning atmosphere. Using PBL can improve and develop independent learning skills, and PBL is better than the DI model in learning physics (Aziz et al., 2014). The PBL model provides a learning process for students to have high-level thinking skills such as critical thinking, problem solving skills, and creative thinking (Sahyar et al., 2017). In learning physics, it has also been found that the PBL model is more effective than the DI model in motivating learning and developing physics problem solving abilities (Argaw et al., 2017). Learning motivation and problem solving abilities are two indicators of students' critical thinking ability in learning physics. In addition, learning motivation is also a domain of social attitudes, which can have a positive impact on developing students' critical thinking ability in learning physics.

Based on the background of the problem above, then the formulation of the problem sought for the solution in this study is (1) Is the PBL model superior to the DI model in achieving critical thinking skills for students in learning physics? (2) Are there differences in students' critical thinking ability in learning physics between those who have high social attitudes and those with low social attitudes? (3) Are there interactive effect between physics learning models and social attitudes towards students' critical thinking ability?

Theoretical Framework

Problem-Based Learning

One accommodative learning model for developing students' critical thinking skills is problem-based learning (PBL). The purpose of using PBL is that students have the ability to think critically, analytically, systematically and logically to determine alternative solutions to problems through exploration of empirical data to foster scientific attitudes (Santyasa, 2017). Selcuk (2010) states that PBL in addition to equipping students with knowledge, can also be used to improve problem solving skills, students' critical and creative thinking ability in learning. PBL uses learning strategies by arranging problems designed for the acquisition of students' critical knowledge, skills for team participation, problem-solving skills, and self-learning strategies (Maloney, 1994).

PBL is a student-centered learning approach that enables students to be active participants in problem solving, answering questions, working together in learning, working in teams to solve problems or projects, and growing awareness that learning is their responsibility. PBL is independent learning, student-centered, independent style guided by the teacher or facilitator (Abou-Elhamd et al., 2011). PBL is innovative learning that serves students as active learners (Prayekti, 2016). In the PBL model, students are encouraged to take initiatives in building their own knowledge (Lee et al., 2010). The PBL model provides a learning environment that accommodates the potential of students' initial knowledge, so it is not appropriate for them to come to class to be seen as carrying a blank head, but able to bring a unique and different framework between them in conducting learning (Chakravarthi, 2010; Efendioglu, 2015). PBL characteristics are very potential for students to develop critical thinking ability in learning.

The PBL model has five syntax, namely: (1) problem orientation, (2) planning solutions, (3) conducting independent group investigations, (4) developing and presenting solutions, and (5) analyzing and evaluating problem solving processes (Arends, 2012) PBL's practical steps become a vehicle for students to practice inquiry. The characteristics of the PBL Model are designed to help students improve their inquiry skills and problem solving skills, social behavior and skills according to the role of adults, as well as independent learning skills for investigating everyday life problems (Nilson, 2016). Although previous research has shown that the PBL model supports independent learning and communication skills, enhances critical skills, creative thinking skills and problem solving skills (Malan et al., 2014), in practice, PBL models still face many obstacles. These obstacles are (1) that students are not accustomed to initiating learning, so they often clash with lack of study time, lack of student discipline, and are not easy to find authentic problems that are more challenging for students in learning (Thompson et al., 2012). (2) The PBL model is still weak in terms of determining the components of inquiry orientation, weak in finding alternative solutions, and difficult in formulating problems and preparing hypotheses (Chakravarthi, 2010). These obstacles are very challenging to find solutions considering the importance of the PBL model in learning.

The solution that can be proposed to overcome these weaknesses is to empower the social aspects of learning. The social aspects of students are closely related to their lives in the real world that is very complex. In addition, real life also requires a collaborative model to accommodate diverse student characteristics. This was accommodated by the PBL model. Practice with the PBL Model begins with complex real life (Ledesma, 2016), is unstructured, and involves interdisciplinary content (Loucky, 2017), engaging in collaborative learning to manage an increasingly diverse student population (Guilherme et al., 2016; Kang et al., 2015). The PBL model can improve independent learning skills and provide a more realistic picture of higher academic challenges, more confidence, better problem solving skills, critical thinking skills, and provide improved communication skills (Malan et al., 2014). The application of the PBL Model can promote students to have motivation, confidence in learning, and be able to improve their ability to solve more complex problems (Caesar et al., 2016; Nilson et al., 2015; Tracey & Morrow, 2017). PBL is a vehicle for students to practice improving problem solving based on social behavior that is appropriate to the role of adults (Nilson, 2016). The characteristics of the PBL model lead to the importance of students' social attitudes as an integral part of physics learning.

Social attitude

Social attitudes are part of interpersonal intelligence. Social attitudes include 4 (four) main things (Gardner, 1999; Goleman, 2000; Howarth, 2006), namely (1) attitude of group organizing, (2) attitude of negotiating solutions, (3) attitude of maintaining relationship personality, and (4) attitude to do social analysis.

The attitude of organizing groups is a social attitude that is often needed by a student in learning. This attitude includes starting and coordinating efforts to move people. The attitude of negotiating solutions is the talent of a mediator in preventing conflicts or resolving conflicts that erupt. This attitude is the basis for reaching agreement, in overcoming or mediating disputes, competent in the field of diplomacy, law, so as to be able to reconcile disputes. The attitude of fostering personal relationships is often referred to as the ability to empathize and build relationships. This attitude makes it easy for people to enter into the scope of association or to recognize and respond appropriately to the feelings and concerns of others. Students who have this attitude are reliable "team players", reliable partners, loyal friends or business partners, in the business world they are successful as salespeople or managers, or can be great teachers. The attitude of social analysis is an attitude that is able to detect and have an understanding of the feelings, motives, and concerns of others. Understanding the feelings of others will bring pleasant intimacy or a feeling of togetherness. In its best form, this ability can make someone a competent therapist or counselor (Padmadewa&Ismoyo, 2017).

Critical thinking

Critical thinking ability has been defined and measured in a number of ways, but usually involves the ability of individuals to identify central issues and assumptions in arguments, recognize relationships that are considered important (Mason, 2017, Moon, 2007), make correct conclusions based on data, concluding information or data, interpreting whether the conclusion is guaranteed to be correct based on the data provided (Facione, 2013; Mulnix, 2012).

Bahr (2010) states that critical thinking is an important goal of the education sector. Duron (2006) also states that critical thinking is the ability to analyze and evaluate information. Correspondingly, Kulekci and Kumlu (2015) state that critical thinking encourages individuals to analyze evaluate and explain through interpreting ideas from a broader perspective. According to Adeyemi (2012), critical thinking has two components, namely the skills to produce and process information and trust and the habit of using their skills to guide behavior based on intellectual commitment. The ability to think critically, according to Ennis (2013), is divided into 6 dimensions, namely (1) formulating a problem, (2) giving an argument, (3) making a deduction, (4) doing an induction, (5) conducting an evaluation, and (6) decide and implement. These dimensions each have indicators and sub-indicators that support the development of critical thinking skills. Thus, thinking critically is thinking not only about how one can answer a question but also about how to get the answer systematically and precisely.

Method

Design, population, and sample

This quasi-experimental study uses a non-equivalence post-test only control group design. The study population was 15 classes (584 students) who came from SMA 4 and SMA 6 Denpasar. The sample was chosen by random assignment technique to determine 2 sample classes in each school. Based on the sampling technique, in Denpasar 4 High School selected the XI MIA 4 class (38 students) who studied with the PBL model and XI MIA 7 class (37 students) studied with the DI model. In Denpasar 6 High School students selected in class XI MIA 1 (37 students) who studied with PBL models and XI MIA 4 classes (38 students) who studied with the DI model. Thus, the total number of samples is 4 classes (150 students, or 25.7% of the total population), 2 classes (75 students) study with PBL models and classes (75 students) study with DI. Because the data analysis uses 2x2 ANOVA, then each group was sorted according to 33% HAS (25 students) and 33% LSA (25 students) in both the PBL group and the DI group.

Research Treatment

The research treatment was carried out 5 times face-to-face meetings with a duration of 3 hours. Each meeting, the treatment is carried out in 3 stages, namely introduction, core activities, and closing. Before students get research treatment, both in the PBL and DI groups, they answer the 30-minute social attitude questionnaire.

In the treatment with the PBL model, the preliminary activities carried out were: delivering the opening greetings, absorbing the students while checking the readiness of students to take part in the learning, conveying SK, KD, and learning indicators to be achieved, dividing students into 7 heterogeneous groups of sex and ability levels high, medium and low in each group.

The core activities of the PBL model consist of stages: 1) problem orientation with student activities: (a) reviewing problems related to the concept of sound waves and light waves presented in the form of LKS, (b) receiving instructor guidance in analyzing problems in accordance with initial knowledge possessed by students. 2) Planning a solution, with student activities: (a) in groups collect data / information from various sources (literature / internet) about the concept of sound waves and light waves presented in the form of LKS, (b) conduct literature / internet studies for find the concept of sound waves and light waves. 3) Conduct independent group investigations, with student activities: (a) make a small note / resume about the problem given and write it on a worksheet, (b) discuss the results that have been obtained in the group. In addition the instructor also observes every activity carried out by students in his group. 4) Develop and present solutions with student activities: (a) present the results of the group discussion, (b) submit the results of the investigation based on the problem under study, (c) collect group work reports and those that have been revised based on class discussions. 5) analyze and evaluate the problem solving process with student activities: (a) analyze the results of problem solving, (b) evaluate the results of problem solving analysis, (c) work on written quizzes individually.

The closing activities in the PBL model are: (a) concluding the learning that has been done, (b) giving the students homework as enrichment, (c) delivering the material to be discussed at the next meeting, (d) delivering the closing greetings.

In the treatment of the DI model, the preliminary activities carried out by the instructor are: opening the lesson by saying the opening greeting, conducting student attendance to check the attendance of students, conveying competency standards, basic competencies, indicators, and learning objectives, providing motivation by exploring the benefits obtained by studying the material of sound waves and light waves.At the core activity, the DI model is carried out by the instructor with steps 1) phase explaining the subject matter of the concept of sound waves and light waves, 2) presenting material step by step, 3) asking students about the concepts described, 4) sharing Student worksheets to be answered by students in a classical group, 5) asking students to collect the results of their discussions that have been poured into group reports, 6) giving motivation to students who are less active in the group.

In the closing stages of learning with the DI model, the instructor takes steps: asking the students about the material that is not yet understood, asking some students to conclude some important concepts from the material that has been studied, conveying the material discussed at the next meeting, delivering closing greetings.At the 6th meeting, students in the PBL and DI groups worked on a 100-minute critical thinking ability test.

Instrument

Critical thinking ability (PSA) Test

The CTA test is set at 12 items. The test material includes 9 sub-topics of wave and optics for XI of SMA. The 12 items of the CTA test are spread into six dimensions of critical thinking, namely formulating problems, giving arguments, making deductions, implementing, inducing, and evaluating. CTA tests are arranged in the form of essays with the rubric of each item using a scale of 0-5. The results of the trial set 12 items of critical thinking instruments used in collecting data. The different power index (IDB) of this instrument moves from 0.21 to 0.50, the item difficulty index (IKB) moves from 0.37 to 0.70, and the item-total correlation coefficient (r_{xy}) moves from 0.37 to 0.64. Cronbach's alpha coefficient of 12 test items stating the reliability of critical thinking instruments was 0.79 with high qualifications.

Social Attitude (SA) Questionnaire

The scale of social attitudes is adapted from Gardner (1999), Goleman (2000), and Howarth (2006) conception which includes 4 main dimensions, namely 1) organizing group attitudes, 2) attitude to negotiation solutions, 3) attitudes to maintaining personal relationships, and 4) attitude in carrying out social analysis. The four dimensions of social attitudes are translated into 30 items of instruments of social attitudes. Each item uses a Likert Scale by removing neutral elements, so the scale is degraded 1-4. The results of the trials in 291 subjects showed that the total correlation coefficient of the social attitude questionnaire items moved from 0.36 to 0.60 with the reliability of 30 items being 0.91 with very high qualifications.

Analysis Technique

To test the differences in the effect of PBL models compared to the DI model on students' critical thinking ability in learning physics, the research data were analyzed by inferential statistics with the 2x2 ANOVA technique. To test of the results of the analysis, a significance level of 5% was used.

Results and Discussion

The descriptive analysis of the average critical thinking ability (CTA) in each category of problem-based learning (PBL) versus direct instruction (DI) and high social attitude (HSA) moderator versus low social attitude (LSA) categories was presented. in Table 1.

Table 1. Qualification of each Mean (M) and Standar Error (SE) of SA on each independet/moderator variable

Ind/Mod Variable	Dependent Variable	Mean	SE	Qualification
PBL	CTA	36.860	0.561	Very low
DI	CTA	33.020	0.561	Very low
HSA	CTA	37.640	0.561	Very low
LSA	CTA	32.240	0.561	Very low

Based on Table 1, it appears that critical thinking ability (CTA) in each category of highly qualified variables is very low.

Furthermore, the results of 2x2 analysis of variance (ANOVA) are presented to answer the research questions. As an assumption Anova is a normally distributed data and the variance between two average values is homogeneous. The results of the analysis show that the CTA data in the PBL, DI, HSA, and LSA groups is normally distributed. The results of analysis of variance homogeneity indicate that the CTA variant between the PBL and DI models is homogeneous, as well as the variance between HSA and LSA is homogeneous. The next step is to conduct an 2x2 Anova analysis of the influence of the learning model (PBL versus DI) and social attitudes (HSA versus LSA) on the CTA. The results of the analysis are presented in Table 2.

Table 2. The 2x2 Anova of PBL model versus SA effect on the CTA

Source	Sum of Squares	df	Mean Square	F	Sig.
Model	368.640	1	368.640	23.452	0.000
Social	729.000	1	729.000	46.377	0.000
Model*Social	268.960	1	268.960	17.110	0.000

Table 2 shows 3 (three) results of the analysis. First, based on the source of influence of the learning model (PBL versus DI) on the CTA, it was found that the statistical value F = 23.452 with a significance number Sig = 0.001. The significance numbers are smaller than 0.05, so CTA differs significantly between students who study with the PBL and DI models. Based on Table 1, the mean CTA in PBL study group was M = 36,860 with SE = 0.561 and in DI was M = 33,020 with SE = 0.561, which means that significantly CTA in PBL was higher than CTA in DI. Thus, the first research question has been answered, that the PBL model is superior to the DI model in achieving critical thinking skills for students in learning physics.

Second, based on the source of influence of social attitudes (HAS versus LSA) on CTA, a statistical value of F = 46,377 was found with a significance number Sig = 0.001. This significance number is smaller than 0.05, so CTA differs significantly between students who have HSA and LSA. Thus, the second research question has been answered, that there are differences in CTA of students in physics learning between those who have HSA and those with LSA. In Table 1 it appears that the mean CTA in the HSA group is M = 37,640 with SE = 0.561 and on LSA is M = 32,240 with SE = 0.561, which means that significantly CTA in HSA is higher than CTA in LSA.

Third, based on the source of the interactive influence between the learning model and social attitudes (Model * Social) on the CTA, it was found that the statistical value F = 17,110 with a significance number Sig = 0.001. Because the significance number is smaller than 0.05, the third research question has been answered, that there is an interactive influence between physics learning models and social attitudes towards students' critical thinking abilities. The profile of interactions between learning models and social attitudes is shown in Figure 1.

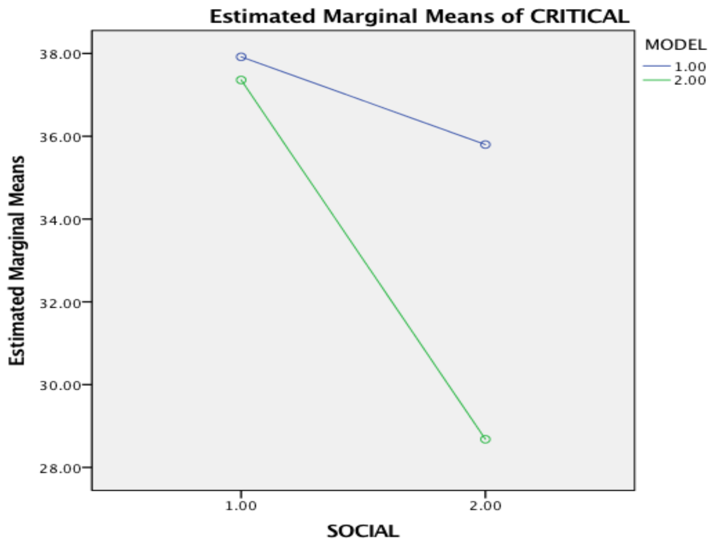

Figure 1. Interaction profile between PBL and SA variables in achieving CTA

In Figure 1 it appears that both PBL models and DI models produce optimal CTA on HSA. This means that both learning models (PBL and DI) react strongly to HAS in achieving CTA.

Discussion

Critical thinking ability (CTA) is one of the skills needed in the 21st century. Therefore, CTA in physics learning in high school must be developed. However, efforts to develop CTA students experience obstacles, because physics learning to date tends to be nuanced to direct instruction (DI). Therefore, the problem-based learning (PBL) model in physics learning is needed to develop the CTA. PBL applications cannot be separated from the potential of social interaction between students through collaborative learning. This study aims to analyze the effect of PBL versus DI on CTA in terms of students' social attitudes.

The results showed that PBL had a superior effect compared to the DI model in achieving the CTA. The results of this study are in accordance with the results of previous studies (Celik et al., 2011; Istikomah et al., 2017; Jatmiko et al., 2018; Padmadewa&Ismoyo, 2017; Siew &Mapeala, 2016). The advantages of PBL compared to DI are due to the design of PBL models planned so that students have the ability to think critically, analytically, systematically and logically to determine alternative solutions to problems through exploration of empirical data to foster scientific attitudes (Santyasa, 2017). In addition, PBL design is also planned so that students are able to do independent learning (Abou-Elhamd et al., 2011), PBL is full of innovation that encourages students to become active learners (Prayekti, 2016), students are encouraged to take initiative in building their own knowledge (Lee et al., 2010).

Comparatively, PBL models are superior compared to DI in achieving critical thinking skills in physics learning, but quantitatively these results are still far below the success criteria in school. The average value of critical thinking skills obtained by students in the PBL group was M = 36,860 with SE = 0.561 and in the DI group was M = 33,020 with SE = 0.561 each on a 100 scale. This achievement showed that students' critical thinking skills were in the very low category and have not reached the criteria for school success. This is a challenge for students and instructors in the next PBL application in learning physics. It was realized that the application of the PBL model in this study became a relatively new thing for students, so students needed enough time to adapt. In addition, students must make fundamental changes in mindset in learning physics with the PBL model, because so far they are accustomed to traditional learning.

To achieve the criteria for success, students need more time to change their views in the face of learning innovations (Çil&Çepni, 2015). Innovation in learning must be sought in such a way as to increase the efficiency and productivity of learning. If there is no significant effort applied in learning, then there is no effect on achieving the success criteria, so there is no increase in productivity (Serdyukov, 2017). However, changes in views for students are not easy, especially in a short time (Schwartz, 2014). Changes in the views of students are included in innovative behavior, whose goals must be known and understood by the students themselves, so that changes to the achievement of criteria of success may occur (Heick, 2014).

When viewed from the students' social attitudes in physics learning, the study found that high social attitude (HSA) was superior to the low social attitude (LSA) in achieving CTA. In addition, this study also found that PBL models and DI models tend to interact strongly with HAS in achieving CTA. This means that LSA is less accommodating for students to achieve CTA optimally. This is because the characteristics of physics lessons are often perceived negatively by students. Most students regard physics as a difficult subject during high school and become more problematic when they are in college (Guido, 2013).

Attitudes can damage students' perceptions of physics lessons and affect their retention rates. Students' attitudes and interests can play an important role among students who study physics, and attitudes imply evaluative reactions that are beneficial or detrimental. Attitudes can be shown in the form of beliefs, feelings, emotions, or individual behaviors that greatly influence student behavior in learning (Guido, 2013). Students' positive attitudes toward physics are highly correlated with their physics achievements (Guido, 2013). If students have negative social attitudes towards physics, then they do not like to study physics and also do not like physics teachers. The social attitudes of students who are bad about physics and physics teachers cause them to be less active in digging for information, less skilled in problem solving, less confident, and unable to act like experts when they solve physics problems. The support of students' social attitudes in learning can build a new culture of excellence in learning, so it is very important to strive for success (Serdyukov, 2017).

Conclusions and Implication

The PBL model is superior to the DI model in achieving students' critical thinking skills in physics learning. Although the critical thinking skills achieved by students who study with the PBL model are higher than the DI models, the students' critical thinking skills produced by the two models are categorized very low and have not reached the criteria of success. Higher critical thinking skills are achieved by students who have high social attitudes. Both PBL models and DI models interact strongly with high social attitudes in achieving critical thinking skills. The implications of this study include: (1) The design of physics learning with the PBL model is sought to be a vehicle for students to develop higher social attitudes, (2) Application of PBL models in physics learning to be preceded by socialization to students about usefulness learn with PBL, so that they can encourage them to make a change of mind quickly and have a positive perception of physics learning, which will lead to the development of optimal critical thinking ability.

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