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Encourage Student's Critical Thinking Skills Through Questioning on Simple Machine Materials

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Abstract: This study aims to encourage students' critical thinking skills with teacher questions in the learning design defined by Bloom's Taxonomy. The research took data from the teacher's list of questions and students' answers during the learning process which was carried out for three meetings. Learning activities are carried out for class VIII which consists of 33 junior high school students on simple machine material. Data collection used non-participatory observation and document content analysis to analyze the teacher's questions with Bloom's Taxonomy which became the criteria set for the level of questions. The results of the analysis showed that the distribution of high-level questions reached 54.05% with a total of 20 questions and 45.95% of low-level questions appeared with a total of 17 questions. Student activity in the learning process is observed and a checklist is carried out with the instrument showing the emergence of sub-critical thinking skills in student answers. Students experienced an increase in practicing critical thinking in their learning process. Overall, students critical thinking skills were observed at 73% in three meetings. Based on the results of this research, questioning in the class has been encouraged by ongoing learning that trains students' critical thinking skills.

Keywords: Questioning, Critical thinking, Simple Machines

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INTRODUCTION

The rapid changes in global education directly affect every aspect of education including the skills that students must master and the teaching strategies used. Critical thinking skills are one of the higher order thinking skills (Dholo et al., 2019) and are considered a fundamental and essential skill in 21st century learning (Haviz et al., 2018; Kim et al., 2019; Redhana, 2019). Therefore, learning that involves HOTS really needs to be developed by teachers in learning. HOTS learning is learning oriented to higher order thinking skills that invites students to think critically, creatively, collaboratively, and communicatively (S, Wiwik; Asmira, O; Ariyana, Y; Bestary, R; Ari, 2018) and (Salbiah M.H et al., 2015) teachers play a role in guiding students to engage in higher order thinking to build critical, creative, logical, reflective, problem solving and metacognitive thinking skills.

Critical thinking is most commonly used in educational circles today. Critical thinking is one way to solve problems based on logic, opinions, and provide reasons for cause and effect (Rahmawati, E et al., 2019). Concept of critical thinking must be understood as involving logical, reflective, and objective thinking activities based on evidence, not assumptions. In addition, Fisher also defines critical thinking as a skill in actively interpreting by evaluating and observing then communicating information and making an argument (Fisher, A., 2011). From some of the definitions above, it can be concluded that critical thinking is an active process that requires a person to have skills in reasoning, decision making, reflective thinking, and problem solving. Thus, the concept of critical thinking is in line with the concept of science learning which is related to how to find out about nature systematically, so that science is not only mastery of a collection of knowledge in the form of facts, concepts, or principles but also a process of discovery (Gholamian, 2013).

In learning science in the classroom, teachers need to design and facilitate learning process activities so that students are active and challenged to think critically by questioning all the information or knowledge they receive. One of these things can be done by varying the simulation provided in the provision of learning materials and maximizing question and answer activities in class. In science learning, asking questions is a method that is often used by teachers to direct students to think critically. Quality questions can lead students to think scientifically and help students construct their knowledge (Hu et al., 2019).

The definition of asking is a teacher's utterance which is usually used as an activation technique in teaching, especially in Initiation - Response - Feedback pattern. The teacher's questions are not always in the form of interrogative sentences but can appear in the form of other responses such as statements or commands. In addition, asking questions can also be used to get students' verbal responses obtained from remembering simple to abstract information, the process of applying, synthesizing, and evaluating information (Zepeda in Feng, 2014; Stobaugh, 2013). Other researchers state that the ability to ask questions of teachers can guide students to thoughtful and reflective answers and thus can reach a higher academic level (Samson et al., 1987). Furthermore used Bloom's Taxonomy to categorize the level of questions (Alfieri et al., 2011).

Simple Machine is one of the important materials taught in class VIII semester one of junior high school. Simple Machines are generally taught with just theory and

simple demonstrations. Students are less enthusiastic and have difficulty determining the mechanical advantage of simple machine tools that are very close to students' daily lives. It is hoped by asking questions about their real everyday experiences, students are expected to be more critical in understanding and applying their knowledge in solving problems in life. By being equipped with the theory of tool work and the principle of mechanical advantage of various simple machines, it actually helps students in reasoning scientific material through simple objects around them. Even at an advanced stage it is hoped that it can stimulate the imagination of students to engineer their own products. In simple machine material students can apply it in everyday life to make work easier (Fatonah, S et al., 2020)

Previously, there had been a lot of educational research related to simple Machines materials and critical thinking skills. Several studies examine the application of learning models to improve students' conceptual understanding in simple machine material (Candra et al., 2019). Other research modify learning media by using interactive multimedia to increase student motivation and learning outcomes (Octafiana et al., 2018). Another research that is in line with questioning and critical thinking has been carried out with the aim of obtaining the best types of questions, stimulus, and quiz settings used in the HOTS CBT assessment to improve students' higher-order thinking skills (Sihalolo et al., 2020). Another study to improve critical thinking skills used POE-based worksheets that has a significant effect on the critical thinking ability of impulse and momentum material (Simaibang, W et al., 2021).

Several previous studies have focused more on the final results obtained by students after being given the desired treatment. Therefore, the novelty of this research is to emphasize the learning process of students in the classroom. Questioning activities are intended to present student's conceptual experiences in solving various problems. However, the teacher must also provide the right stimulation to encourage student's critical thinking skills by understand the concepts and principles of simple machines tools. In this study, the stimulus provided could be in the form of stories, pictures and animated videos assisted by HOTS questions to lead students to critically explore information and create further.

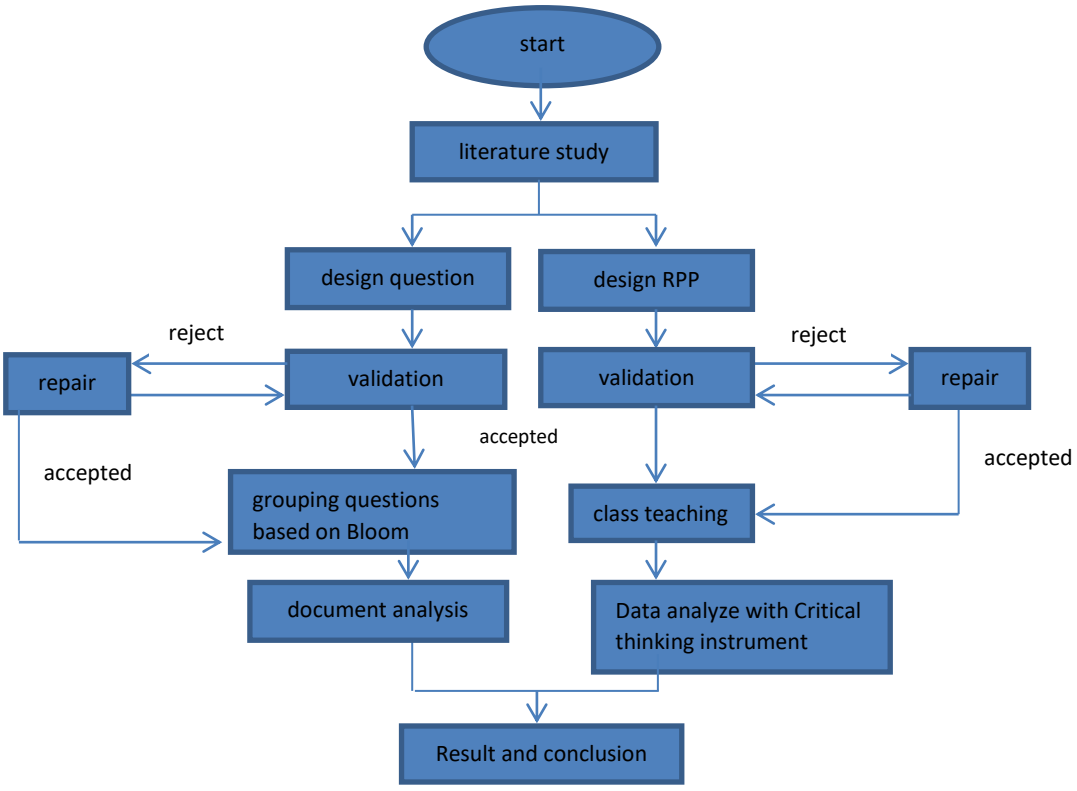
Questioning activities can involve students in critical reasoning and scientific discussion, which involves theoretical assumptions, data evaluation, explanation of pictures, defending opinions, and clarifying doubts (Chin & Osborne, 2008). Research by Santoso has succeeded in developing a questioning technique to practice students' critical thinking skills. The results show that the level of questions that play an important role in critical thinking skills are questions at the level of predictive, analysis, evaluation and inference (Santoso et al., 2018). Then Golding (2011) in his research, trained critical thinking skills with the Richard Paul method on Socratic questions. In his research, Golding combined this method with the pedagogical literature to train students' broader critical thinking. However, some research results found that students still had difficulty in asking questions (Golding, 2011; Katchevich et al., 2013). Which is considered to contribute to the low critical thinking ability of students (Eshach et al., 2014).

From the description above, it can be assumed that the level of students' thinking is strongly influenced by the questioning activities in class. Therefore, asking questions in learning can be a strategy to lead students to higher order thinking (Conklin, 2011; King et al., 2003) and foster critical thinking (Brookhart, 2010) which will be the focus

of this research. Based on the description that has been stated above, the researcher intends to design learning designs and produce learning trajectories using the HOTS learning context with the questioning.

METHOD

This study aims to describe and investigate teacher questions in learning design with the categories of question as defined by Bloom's Taxonomy which served as the criteria set for the level of questions. This study uses descriptive research with qualitative data using content analysis studies. The research took data from the teacher's list of questions and students' answer during the learning process which was carried out for three meetings. Learning activities are carried out for class VIII.10 that consist of 33 junior high school students on simple machines material. The following is the research implementation chart :



Collecting data used non-participatory observation and document analysis and used content analysis to analyze the teacher's questions with Bloom's Taxonomy which grouped into 2 categories, namely High Level Questions and Low Level Questions. Observation sheets are needed to focus on the points of the investigation. This research is a preliminary research for design research which aims to use the question method to practice critical thinking skills students. Then, the data is entered into a table containing a column for categorizing teacher level questions based on Blooms's Taxonomy. Thus, describing the distribution of question level categories in the learning design to train students' critical thinking skills. The critical thinking skills instrument were used consist of 12 statements of the critical thinking skills formulated by Ennis (1985) :

Table 2. Category Level of Question

Critical Thinking Skills	Sub Critical Thinking Skills
Provide a simple explanation (elementary clarification)	Focusing questions
	Analyze arguments
	Ask and answer an explanation or challenge
Build basic skills (basic support)	Match the source
	Observe and consider the results of observations
Summarize (inference)	Deduce and consider the results of the deduction
	Induce and consider the results of induction
	Make and consider value decisions
Provide further explanation (advanced clarification)	Define terms and consider them
	Identify assumptions
Develop strategies and tactics	Define action
	Interact with others

RESULT AND DISCUSSION

This study applies intentional teaching through questions. Questions that are effective in teaching is marked by the difference between being a facilitator of learning opportunities or simply using of other people's ideas. By using documentation to reflect on teacher formulated questions, teachers become more thoughtful about their questions and learn how to formulate better questions that help teachers develop better understanding. Many study found that questioning is an important cognitive process that enhances teaching and learning. The quality of the questions asked by the teacher plays an important role in training students' critical thinking skills. Asking good contextual questions is a skill that requires the teacher's creative intervention to facilitate learning apart from providing targeted stimuli. Below is the result of grouping the teacher's list of questions based on 6 categories of questions by Bloom :

Table 1. Category Level of Question

Questioning Category	Category / Skill	CognitiveTasks	Type of Question
LOWERLEVEL	REMEMBER Memorizing Recalling Identification Recognizing Remembering	Define Describe Label List Match Recognize Recall Reading Mention Reciting Make lists Underline Matchmaking Give definition	Have you seen...? What is the child in the picture…? State the name of the tool / object .....? What happened to you when …..? What is the use of pulleys that you often encounter in everyday life? What is a simple machine? do we need it?
	UNDERSTAND Describing one's own words Interpreting Organization and selectionof facts and	 Explain Meaning Interpret Tells Gives examples Summarizes	What is the function of the tool / object? If you want to do it, choose which way? why ? Why are bicycles still popular, even though there are many more sophisticated modern means of

	ideas Paraphrasing Translating from one medium to another	Compares Classifies Predicting Estimating	transportation? If later it is the era of robots/machines, are simple airplane tools still used by humans? Why is it called a simple machine huh? How is it different from modern aircraft?
	APPLY Applying knowledge to actual situations	Apply Choose IllustrateShow Use Practice Demonstrate Implement Determine Processing Counting	Is there any other way you have seen/done….? Why do you ride your bicycle to school? Are there any disadvantages to using pulleys? Why do we need pulleys? Give examples of inclined planes that you often encounter? Do all the objects around you need to be fitted with wheels? Why ?
HIGHERLEVEL	ANALYSIS Applying information to produce some result. Finding the underlying structure of communication. Identifying motives. Problem-solving. Separation of the whole into parts. Subdividing something to show how it is put together.	Analyze Calculate Categorize Compare Compile Differentiate Distinguish Elicit Examine Imagine Outline Separate Subdivide	Are there any special requirements or characteristics of these tools so that they are classified as simple machines? Why does the change in the direction of force on a fixed pulley whose KM is 1 still provide convenience for its users? What are the differences and similarities between a fixed pulley and a movable single pulley? Why are the pulleys used in ports and high-rise building construction sites so large? If asked to choose 1 of 2 stairs, one is steep but short and the other is sloping but has more steps. Which would you choose, Why? Does the length of the inclined plane affect the size of the KM? Does the angle of inclination of the inclined plane affect the size of the KM Does the type of lever affect the amount of KM generated? What affects the size of the KM on the lever?
	EVALUATE Making decisions on topics of interest. Solving disagreements or differences of opinion.	Proving Defending Validating Comparing Concluding Criticizing Assessing Evaluating Giving suggestion Giving arguments Interpreting	Does the diameter of the pulley affect the KM? Does the length of the power rope affect the size of the force applied? Beni and his father play seesaw in the city park. When the pedestal was in the middle of the seesaw, Beni was unable to lift his father. How can Beni and dad play the seesaw in a fun way? What factors can increase the mechanical advantage of the pulley? What are the recommendations for using

	Recommending Decide	inclined planes in your daily life? What should be done in modifying a simple machine to increase the KM of the inclined plane and levers?
CREAT		In your opinion, what type of simple
Combining ideas to create a new whole.	Categorizing Combining	machine helps your work the most? Explain whether all types of levers can
Create a unique, original product that can be a physical object or in verbal form.	Composing Designing Creating Designing	reduce the force applied? What conclusion did you get from our lesson today?
Creation of views, choicesor conclusions.	Reconstructing Assembling Summing up Make a pattern	What are the real benefits of learning simple machine material? What are the benefits of ..... in everyday life?

(Type of Questions based on Bloom Taxonomy revision)

In the first stage, the list of questions was grouped into categories of low-level questions and high-level questions defined by Bloom. The teacher's questions have been classified into two categories: HOTS and LOTS. Where for LOTS category questions only need to remember one fact and do not involve critical thinking (remembering, understanding, and applying). While the HOTS questions involve examining, assessing, and developing what allows students to demonstrate their understanding of a topic, situation, or response to a particular problem (analyze, evaluate, and create).

The table above shows the distribution of teacher questions in each question level category. After being collected, similar questions were found in each meeting. In the learning design planned by the teacher, there are 63 questions, but in the list of questions collected in this study, only 37 questions were analyzed. This is because some of the questions at the beginning of the learning or stimulus activity and the reflection activities at the end of each meeting are the same type of questions, only the content differs according to the sub-materials taught at each meeting. So that the researcher considers that it is not necessary to enter the type of similar questions into the analysis table for the category of questions. From the results of grouping the questions into 6 categories as shown in the table above, the following data were obtained :

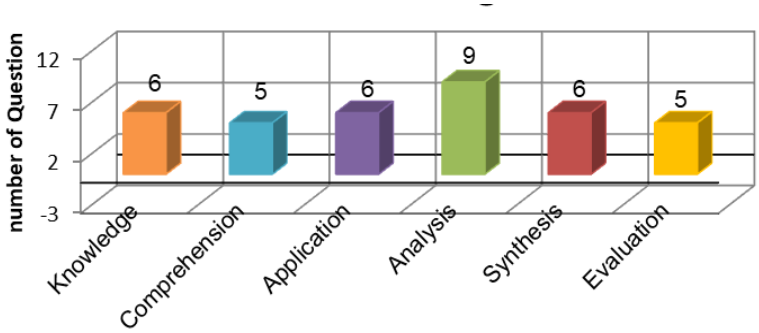


Chart 1. Question Categories

From the chart above, it can be seen that the question category grouping consists of 6 levels of questions. The questions that arise at the first level, knowledge, are mostly questions given by the teacher in the preliminary activity. In the introductory activity the teacher asks questions with the aim of helping students remember knowledge, state understanding, and generate motivation. If added to the previously eliminated questions, the number of questions at this level is the most. Almost all types of questions are asking students to name simple tools that are often used in everyday life, students' prior knowledge about the functions of these tools and see students' responses to an event or occurrence. The initial activity that brings the everyday environment into the classroom aims to provide a trigger in learning.

The grouping of questions at the second level, comprehension, consists of 5 questions. After analyzing that all the second level questions appeared in the early activities of the learning process. The questions at the comprehension level aim to ask for opinions, compare, and predict an event in general. In addition, questions at this level aim to ask students to express their opinions openly about their previous experiences in using simple machine tools.

The Q3 level, application, consists of 6 questions. The questions at this level are given by the teacher in the core activity when students are discussing in their groups. Problems at the application level aim to lead students to apply the knowledge they have just received to actual situations in everyday life. This question is designed to ask students to express their opinions about the benefits of using simple tools, with the aim of students being able to conclude that using simple machines makes work easier or human effort is smaller. In general, they can describe the working principle of a simple machine in reducing the effort.

Furthermore, at the Q4 level, analysis, consists of 9 questions. Most of the analytical questions were found in the lesson design plans made by the teacher. Most of the analytical questions appear in the core activity of the problem statement section. The analytical questions raised aim to lead students to identify important parts of the material that students must understand. The form of questions planned at the analysis stage is to lead students to solve problems given by the teacher in modules and group discussions. The problem is designed to analyze the parts of each type of simple machine to show how they affect the mechanical advantage of an instrument. Knowledge of how each part contributes to the size of the mechanical advantage of a simple machine must be built through a process of self-understanding by students, not knowledge given directly by the teacher in the form of a predetermined mathematical formula. Thus, it is hoped that after answering the analytical questions given, students can critically conclude the solution to the given problem.

The synthesis level at Q5 level consists of 6 questions. Most of the questions at the synthesis level are given at the end of the core activity. Synthesis questions aim to combine ideas that have been obtained during learning to create new conclusions. Synthesis questions are expected to lead students to build general principles or concepts of how simple machines work. Assisted by learning activities and collaboration in group discussions, students play a role in concluding the essential subject matter that has been studied at that time.

The last level of Q6, evaluation, consists of 5 high-level questions. Questions at this level are most often planned to appear at the end. Where in this phase students are asked to reflect on important things that they have started from the beginning to the end

of learning. Students are also asked to think about things that are wrong or true about simple plane materials after their initial knowledge. Furthermore, students are also expected to be able to formulate important things and find ways to apply them in life.

From the results of the analysis of teacher questions planned in the learning design that has been carried out, it was found that the questions given were spread out in the learning process starting from preliminary activities to closing and reflection activities. The number of distributions of low-level and high-level questions as a result of the analysis using the question category table by Bloom is as shown in the chart below :

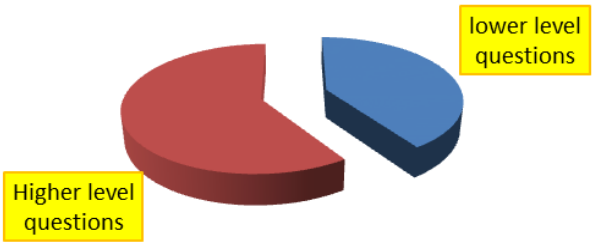


Chart 2. Teacher Question Level

Based on the data above, it can be seen that the teacher planned 45.95% low-level questions consisting of 17 questions and 54.05% high-level questions with 20 challenging questions. The lower number of low-level questions was due to a reduction in the number of questions of the same type that appeared at each meeting. The number of questions reduced was 26 questions, 13 questions asked about the names and functions of objects, 9 reflection questions asked about the benefits of learning and conclusions, and 4 questions asked about student events or experiences. The lower questions are intended to make students only recognize one fact, respond to the level of students' knowledge, understanding, and remember the material in their own words from what they have previously read or what the teacher has taught (Theresia, 2021).

In this learning design plan, the teacher raises most of the low-level questions in the initial activity which aims to stimulate and prepare students to learn. Students do not need to employ higher order thinking skills to solve problems at this level because they are simply using their fundamental knowledge to locate information. Low-level questions are expected to significantly impact to the overall learning process even though they do not train students' critical thinking skills. Low-level questions are believed to significantly affect in learning process to generate students motivation. Students' critical thinking processes must be preceded by great curiosity and high motivation, in line with research conducted by Kurnianto & Haryani, 2019, stating that additional variables of motivation are needed to improve the process of critical thinking skills and student learning outcomes.

High-level questions appeared as many as 54.05% of which most of the questions were spread out in the core activities of the learning process. The most questions arise at the Q4 level, with 9 analysis questions, then Q5 with 6 synthesis questions and at Q6 level consist of 5 evaluation questions. The high-level questions that arise the most are the Q4 level.

Furthermore, the increase in students' critical thinking skills was observed with previously validated critical thinking skills instruments. Critical thinking skills are

obtained when students are familiar with a concept, and try to relate it to the new knowledge they receive. Teachers can help students discover the relationship between old and new knowledge by providing higher-level stimulation and questions. The researcher observed by adjusting the questionnaire document with and analyzing the learning design document made by the teacher. The analysis was carried out by collecting a list of teacher questions given during the learning process starting from preliminary activities to reflection activities at the end of learning in three meetings. Analysis level questions encouraging students to try to answer the problems presented by the teacher in the classroom can be seen from the table of observations of students' critical thinking skills below:

Table 3. Sub Critical Thinking Skills Appearance in Learning Process

Sub Critical Thinking Skills	**Meeting-1**	**Meeting-2**	**Meeting-3**	**% Occurents**
Focusing questions	72%	81%	78%	77%
Analyze arguments	48%	69%	69%	62%
Ask and answer an explanation or challenge	78%	72%	81%	77%
Match the source	78%	72%	81%	77%
Observe and consider the results of observations	69%	75%	72%	70%
Deduce and consider the results of the deduction	48%	69%	78%	65%
Induce and consider the results of induction	60%	72%	78%	70%
Make and consider value decisions	69%	75%	66%	70%
Define terms and consider them	81%	96%	75%	84%
Identify assumptions	54%	51%	63%	56%
Define action	72%	72%	72%	72%
Interact with others	93%	90%	98%	94%
AVERAGE TOTAL APPEARANCES	**69%**	**75%**	**76%**	**73%**

The table above represents the emergence of sub-critical thinking skills from 33 grade 8.10 students who were held in three meetings. From the table it can be seen that students' critical thinking skills were observed during the learning process with a fairly high percentage. There was an increase from the first meeting of 69%, the second meeting was observed at 75% to the third meeting of 76%. Which means that students experienced an increase in practicing critical thinking in their learning process. Overall, students' critical thinking skills were observed at 73% in three meetings.

CONCLUSION

Theoretical assumptions and data evaluation on many research succeeded in developing a questioning technique on class to practice students' critical thinking skills.

The results show that the level of questions that play an important role in critical thinking skills are questions at the higher level of analysis, synthesis and evaluation. Based on the results of the research that has been described previously, the teacher's questions in the planned learning design have encouraged the ongoing learning that trains students' critical thinking skills. This can be seen from the distribution of high-level questions which reached 54.05% with a total of 20 questions. Most of the questions were spread out in the core activities of the learning process. The most questions arise at the Q4 level, with 9 analysis questions, then Q5 with 6 synthesis questions and at Q6 level consist of 5 evaluation questions.

Therefore, all levels of questions that are planned to appear in the teacher's instructional design will still be used in actual research and become a very important part to see the success of practicing critical thinking skills for junior high school students on simple machines material in class VIII. Students are encouraged to think more broadly and deeply, seek information on their own, and find alternative problem solving with collaboration. All of these cognitive processes are set to take place in the classroom in order to help students enroll the critical thinking abilities they require.

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