



Profile of Senior High School Students' Critical Thinking Skills and The Need of Implementation PBL Model Assisted by Augmented Reality Book

Hanandita Veda Saphira, Binar Kurnia Prahani*

Physics Department, Faculty of Mathematics and Science, State University of Surabaya,
Jl. Ketintang, Surabaya, Jawa Timur 60231, Indonesia.

*Email: binarprahani@unesa.ac.id

DOI: 10.24815/jpsi.v6i3.25031

Article History: Received: February 26, 2022
Accepted: June 11, 2022

Revised: May 20, 2022
Published: June 27, 2022

Abstract. Critical thinking skills of students in Indonesia are still very low, then one way to improve CTS is to collaborate learning with real-world problems that can be found in everyday life with the help of existing technology as a learning tool. The purpose of this research was to find out the profile of students' critical thinking skills and the implementation of problem based learning implementation with assisted augmented reality books in high schools, especially on learning physics with parabolic motion materials. The method research is included in preliminary research with a sample of 190 high school students in Surabaya, East Java. Data collection techniques by sharing critical thinking skills tests, student response surveys and interviews of students and teachers. Then the data is analyzed using qualitative descriptive to represent the results of the research. The findings of the study are 1) Students' critical thinking skills are still in the low category. 171 students with low categories, 19 medium categories and none at all high-category students; 2) The lowest indicator of critical thinking skills is interpretation; 3) Teachers still use conventional lecture methods and teaching materials during learning; 4) The implementation of problem-based learning models with integrated AR books is expected to improve students' critical thinking skills on physics materials. It can be concluded that to improve students' critical thinking skills, it is important to innovate learning, especially in physics learning, one of which is the implementation of Problem Based Learning assisted by Augmented Reality books.

Keywords: Augmented Reality Book, Critical Thinking Skills, Problem based learning.

Introduction

The rapid increase in the progress of the times due to globalization which includes the industrial revolution, resulting in the emergence of new challenges, especially in the world of education, which finally emerged a solution in the form of a framework of 21st century learning. Competencies that exist in a 21st century learning framework include a more understanding that emphasizes the knowledge, skills, values and attitudes students need in very daily life, school, at work as well as in their lives (Falchetti et al., 2019; Mishra & Mehta, 2017; Teo, 2019). The learning process should encourage students to gain new experiences, knowledge, skills, and also attitudes that free students to learn, modify and ofcourse change new skills (Okoli & Akpan, 2017). Furthermore, in order to compete in this era, it is not enough to rely only on everyday skills, but must have critical, creative and innovative thinking skills, and interpersonal and intrapersonal skills (Gunadi et al., 2022). The biggest problem that will be in the future is the change in the nature of work, so that education needs to be adjusted through a framework that focuses on the development of students' soft skills, known as 4Cs soft skills education, consisting of critical thinking, communication, collaboration, and creativity, which are closely related to human agency in terms of technology and mechanics (Agustin et al., 2021).

Learning activities require the implementation of basic principles in 21st century learning, consisting of several basic principles including: learning must be based on student centered learning, implement collaboration, link to problem-based contexts in the real world and related to everyday life, learning as a whole, interactive and integrative, prioritize creativity and innovation, use qualified learning media, support metacognition (Asrizal et al., 2019; Muhali, 2019; Mustaqim et al., 2019; Tsabitamia & Nurita, 2021). In the integrated learning activities of 21st century learning, students are expected in order to adapt to the acceleration of technological and

information advances and the emergence of new communication and collaboration patterns such as faith, innovative, productive, creative and contribute to the life of the nation, state and to world civilization (Rahmawati, 2018).

Physics is one of the subjects that have many concepts with a high level of complexity. Physics is one of the sciences that study about the symptoms of nature and the process of occurrence of natural symptoms (Maysyaroh & Dwikoranto, 2021). In physics learning, it should not only focus on concepts and facts, but should be integrated with experience in students so that students can understand scientifically (Rahmadita et al., 2021; Wardani & Jatmiko, 2021). The process of physics learning activities provides space for students to develop 4C's (critical, creative, collaboration dan communication skills) (Alifika & Purwantoutari, 2019; Khoiri et al., 2021; Khoiriyah & Suprpto, 2021; Khotijah et al., 2019).

Critical thinking skills (CTS) in receiving information by reviewing the source of information circulating can be accounted for or not, reading information from various sources summarized into a conclusion (Rezkillah & Haryanto, 2020). CTS of school students in Indonesia are still very low based on data from the programme for international student assessment (PISA, 2018), Indonesia's literacy score is 382 with a rating of 64 out of 65 countries. The problem used consists of six levels (lowest level 1 and highest level 6) (Marudut et al., 2020). Indonesia still has an average score well below the OECD acquisition average, this shows that students in Indonesia still cannot use their CTS, and their learning is still at the level of remembering and knowing a phenomenon (Lestari et al., 2021). CTS are one aspect of problem-solving skills that are covered by analyzing or reasoning, evaluating, and making decisions (Azizah et al., 2018). Based to Reynders et al. (2020), CTS have indicators of evaluation, analysis, and/or systemting releven information to form an argument or get a conclusion that is equipped with facts.

One way to improve CTS is to collaborate learning with real-world problems that can be found in everyday life with the help of existing technology as a learning tool. Innovation is a key tool in the industrial era 4.0 to form students with 21st century competencies capable of critical thinking, creative, collaborative, and communicative thinking (Mulyani, 2019). Augmented reality (AR) technology is beginning to attract the attention of some researchers when teaching physics subjects as part of science education (Fidan & Tuncel, 2019). In order to improve students' CTS, the development of AR-based interactive media that can be accessed using students' smartphones. Become something new in the development of AR-based interactive media in science learning (Syawaludin et al., 2019).

According to the theory developed by Glatthorn and Craft Tripp, project-based learning (PBL) is a constructivist theory-based learning model aimed at encouraging students' interest in learning and active participation in the learning process. It is said that (Pecore, 2012). The PBL model has the characteristics of a student-centered learning model. The PBL model requires students to always think scientifically, developing the way of thinking necessary in the process of learning activities in the 21st century. Through the application of PBL can also develop high-level thinking skills (Syam & Efwindi, 2018). The use of the PBL model is very well used for physics learning. During the learning process using PBL, teachers have a role as mentors in facilitating the alignment of student information and transferring information to students (Putra Wijaya et al., 2021). PBL is closely related to CTS. PBL requires the ability to think critically in exploring various ways of solving or alternative solutions, as well as providing problems that trigger the development of students' critical thinking potential (Susetyo et al., 2021).

Over the last half century, teachers have shown that PBL can be used effectively to improve cognitive and emotional skills in learning (Dolmans et al., 2016; Suparman et al., 2021; Wenno et al., 2021). Some researchers suggest that technology-based PBL has a greater impact on cognitive and emotional abilities than traditional or face-to-face PBLs (Ismail et al., 2018; Phungsuk et al., 2017).

According to Fidan & Tuncel, (2019), mentioning the implementation of PBL with integrated AR in physics learning is one of the effective media that has positive results. However, the challenge profile of the 21st century requires teachers to update learning strategies to support 21st century students (Caena & Redecker, 2019). One of them is by utilizing the capabilities of digital technology. Thus, the application of PBL to support the association with the application of problems in the real world that can improve CTS and AR integration that can increase positive feelings to students in the subject of physics learning.

Based on the above explanation, the purpose of this study is to find out the profile of students' CTS and the application of PBL implementation by assisting AR books in High School, especially on learning physics with parabolic motion materials. The novelty of this study is to bridge the results of previous research as well as to obtain new findings and recommendations related to the profile of students' CTS and the implementation of

PBL with the assisted AR book in High School. How to apply the PBL model in schools, as well as how to profile the level of CTS of high school students.

Methods

This research is a preliminary to data analysis techniques in the form of descriptive qualitative analysis. This preliminary research was conducted by researchers to find out the actual circumstances in school and to add information related to the problem in more detail (Shorey et al., 2020). This study did not test hypotheses. The results of this study are used as considerations to improve innovation models and learning tools in schools that are able to improve the CTS of high school students.

The study was conducted on 190 students of grade X Science at Surabaya, in February 2022, consists of 125 female students and 65 male students. This study used several instruments to collect data, namely (1) a CTS test questionnaire consisting of five indicators (Pradana et al., 2017) on parabolic motion material, (2) teacher interview sheet, (3) student interview sheet, (4) student response questionnaire survey.

This study uses sampling techniques in the form of purposive sampling. The data analysis technique used is to use responses from test questionnaires and survey responses to find out the student's response (Rizki et al., 2021) created using google form (Mashurin et al., 2021). Then, researchers also conducted interviews with teachers and some students. Analysis of the data that has been obtained is used to find out the actual condition and circumstances in high school to the CTS of students. This stage of research is carried out as in Figure 1.

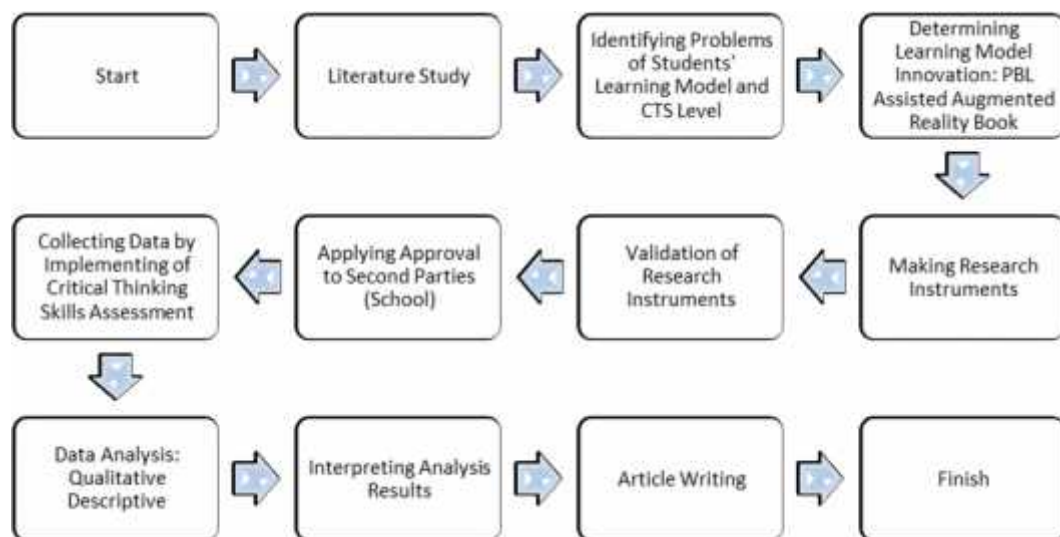


Figure 1. Research stages.

This research aims to find out the profile of students' CTS, especially on parabolic motion materials. The student questionnaire test sheet consists of 8 essay questions from four main indicators of CTS, namely inference, interpretation, analysis, evaluation, and explanation. The selection of the type of problem in the form of an essay is used to present an answer more in-depth than just choosing an answer on multiple choice (Maryani et al., 2021). Furthermore, students are given 10 questionnaires in the form of questionnaire responses to physics learning in school. Then, the level of CTS is calculated through the response of the student's answers. If the response is logical, complete and systematic then the point obtained is 5; if the answer has only two components (logical and complete or logical and systematic), then the point obtained is 3; if the answer only gets one complement, then the point obtained is only 1; And if the student's answer is wrong then the point obtained is 0.

So, the maximum points obtained is 40. Then, to get the final score of each student, then use the following formulation:

$$\text{Final Value} = \frac{\text{Points Earned}}{\text{Maximum Points}} \quad (1)$$

The categories that apply are as follows:

Table 1. Range of categories

Range of Score	Categories
$75 < \text{Score} \leq 100$	High
$45 < \text{Score} \leq 75$	Medium
$\text{Score} \leq 45$	Low

(Rohmah & Prahani, 2021)

Results and Discussion

Students' Critical Thinking Skills on Parabolic Motion Materials

Based on the criteria that have been compiled above, it can be known the values of students' CTS. This research was conducted by giving a writing questionnaire test consisting of eight questions. Each indicator has two questions. Four indicators in problem-solving skills with critical thinking and problem-taking processes are analysis, interpretation, inference, evaluation and explanation (Facione, 2005 dalam Facione, 2015; Seventika et al., 2018). Students are expected to answer based on the problems provided by analyzing the information and then evaluating alternative solutions in the form of statements or arguments, then making a conclusion from all the data and information they can, and explaining straightforwardly the solution of the problem they find (Sunarti et al., 2021). Then, from the answer researchers can conduct an assessment of the student's CTS. Students are expected to be able to analyze the question, then interpret and make conclusions and evaluate the results of their answers based on the indicators in the question. Based on research that has been carried out, the results of students' CTS on parabolic motion materials with PBL using facione indicators are as in Figure 2.

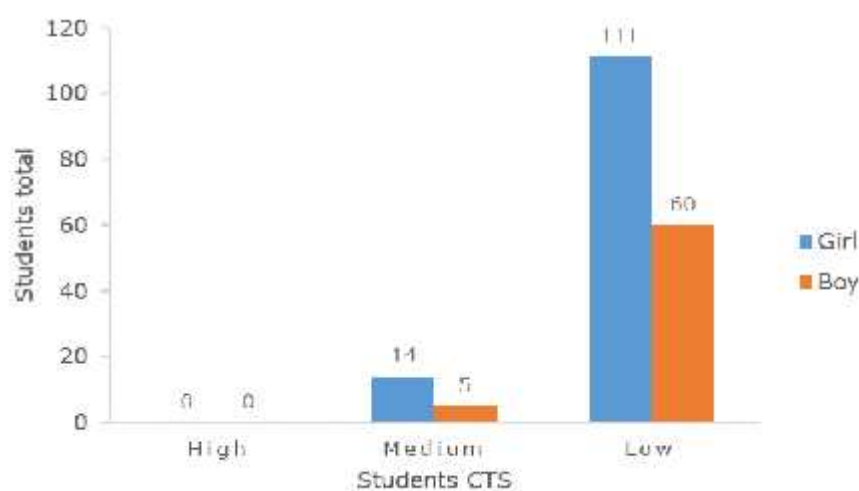


Figure 2. The results of student's CTS assessment.

Figure 2 explained that students' CTS levels are still low, in line with research by Purwanto et al. (2022), both in female and male students. Of the two genders, there are significant differences. The difference occurs at both low and moderate levels of CTS. Uniquely, of all the total students who were respondents, none

got a high level of CTS, both from female students and male students. Figure 2 proved CTS in both female and male students in the low category. The amount of female students who fall into the category of low CTS level is 110, male students number 59, then on medium CTS are 14 female students, 5 male students and none of the students had the category of high-level CTS.

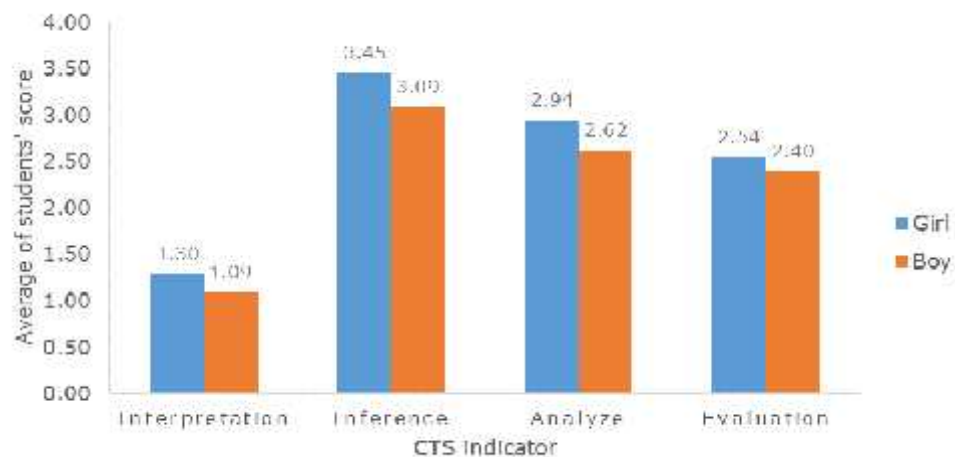


Figure 3. Average of students' CTS of each indicators for boy and girl.

Figure 3 representing the results of research in the form of essay tests that include indicators of CTS, found the average score of each indicator obtained by students. Based on the picture, women have the highest average score on each indicator compared to male students. Although the four indicators are not significantly different. However, we can conclude that the CTS level of female students is still higher than that of male students. This is opposite to research by Darmaji et al. (2021), that shown male students are more superior in science process skills rather than female, but both critically thinking skills are in a good category. Examples of students' answers to the CTS essay test of each indicator, namely achievement, inference, analysis and evaluation are as follows:

1. Interpretation

$$\begin{aligned}
 & \text{6. } v_{0,x} = v_0 = 40 \text{ m/s.} \\
 & X = v \cdot t : v_{0,x} \cdot t = 40 \cdot 2\sqrt{5} = 80\sqrt{5} \text{ m} \\
 & y = v \cdot t : \frac{1}{2} at^2 = v_{0,y} \cdot t + \frac{1}{2} gt^2 = y_0 \\
 & 0 = \frac{1}{2} t^2 = 100 \\
 & t = 2\sqrt{5} \text{ s}
 \end{aligned}$$

Figure 4. Student answers of interpretation.

Figure 4 represents interpretation indicators, students are asked to interpret the understanding on an image of a plane dropping a package at an altitude of 100m, what is the point of position of the dropped package? However, students are more focused on distance grades than the fall in the package. From the answer it can be known that the student's understanding is still fixated on calculations that refer to formulas rather than giving verbal impressions based on theories (Tyas, 2021) that apply to problems in parabolic motion. In this indicator, based on Figure 3 this indicator has the lowest value compared to other indicators.

2. Inference

$v_0 = 50 \text{ m/s}$
 $g = 10 \text{ m/s}^2$
 $t = \frac{2 \cdot 50^2 \cdot \sin 2 \cdot \alpha}{g}$
 $t \text{ terdekat} = \frac{2 \cdot 50 \sin 2 \cdot 75}{10} = \frac{100 \sin 150}{10} = 10 \cdot \frac{1}{2} = 5 \text{ s}$
 $t \text{ terjauh} = \frac{2 \cdot 50 \sin 2 \cdot 45}{10} = \frac{100 \sin 90}{10} = 10 \cdot 1 = 10 \text{ s}$

Figure 5. Student answers of inference.

Figure 5 represents the student's answer to the inference indicator. In this indicator, students are asked to provide conclusions based on student analysis through graphs between distance and altitude with angular manipulation. Almost all students stop providing analysis after getting the results of their formula calculations. The answer is not complemented by further analysis and the main one is the conclusion. This shows that the student still does not understand what they should do with a problem presented (Siagian et al., 2019; Simamora et al., 2018; Wyness & Dalton, 2018).

3. Analyze

$X = \frac{v_0^2 \sin(2 \cdot 45)}{g}$
 $= \frac{50^2 \cdot 1}{10}$
 $= 250 \text{ m/s}$
 $d = \frac{v_0^2 \sin^2 \alpha}{g}$
 $= \frac{50^2 \cdot \sin^2 45}{10}$
 $= 125 \text{ m}$
 $t = \frac{2 \cdot v_0 \sin \alpha}{g}$
 $= \frac{2 \cdot 50 \sin 45}{10}$
 $= 10 \text{ s}$

Figure 6. Students' answers on analytical indicators.

Figure 6 represents the student's answer to the indicator analysis with the problem of whether an athlete can cross a cliff with the components mentioned implicitly. Then, students were asked to create a modernizing image as well as make an analysis of their calculations. However, most of those students did not describe how the model of the problem was. Also, they also did not add an analysis based on the results of the calculations they had done. Thus, researchers feel that students' answers have not met the riteri logical, systematic and complete assessment.

4. Evaluation

$15 \text{ m/s} \rightarrow 15 \text{ m/s} \text{ (B)}$
 $30 \text{ m/s} \rightarrow 30 \text{ m/s} \text{ (A)}$
 Bob Bauri mempunyai jarak paling jauh
 kecepatan lebih besar dari bob

Figure 7. Student answers on evaluation indicators.

Figure 7 shows representing the student's answer to the evaluation indicator. Students are asked to evaluate from two balls thrown horizontally at the same time, at different speeds, which ball has the most distance? Most of them have an inverted understanding of the speed of the ball. As in Figure 7. Ball A should have a speed of 15 m/s while ball B should have a speed of 30 m/s. This results in the lack of precise analysis and evaluation of students to the problems given. Also, almost all students did not explain the evaluation process they did and did not give further conclusions regarding their findings.

Results of Student Response to Physical Learning

After working on an essay test to measure CTS on parabolic motion material, on a subsequent Google Form page, students were asked to fill out their responses to physics learning in school. This response amounted to 10 statements selected with responses strongly disagreed, disagreed, agreed and strongly agreed represented by a scale of 1 to 4. The results of the response questionnaire are represented by Table 2 in addition to providing questionnaires on Google form, researchers also held interviews with students to find out more in depth the student's response to physics learning, especially in school.

Table 2. Students' response to physics learning and CTS in school.

No.	Statement	Answer (%) (n=190 Students)			
		Strongly Disagree	Disagree	Agree	Strongly Agree
Q1	Physics is a fun lesson.	10.00 (19)	44.21 (84)	41.58 (79)	4.21 (8)
Q2	Parabolic motion material is important to understand.	1.58 (3)	17.89 (34)	59.47 (113)	21.05 (40)
Q3	Parabolic motion material is difficult to understand.	4.21 (8)	22.11 (42)	44.74 (85)	28.95 (55)
Q4	Conventional book-assisted lecture methods are often used by teachers rather than laboratory or simulation experiment methods.	4.74 (9)	12.63 (24)	47.89 (91)	34.74 (66)
Q5	You feel comfortable and happy with the learning methods that your current Teacher is doing.	8.42 (16)	24.21 (46)	48.95 (93)	18.42 (35)
Q6	You've done learning activities to improve CTS.	3.16 (6)	20.00 (38)	56.32 (107)	20.53 (39)
Q7	You've been trained with CTS tests frequently.	2.63 (5)	22.11 (42)	50.53 (96)	24.74 (47)
Q8	CTS are important to teach in school.	1.05 (2)	8.42 (16)	43.16 (82)	47.37 (90)
Q9	You know what AR is.	20.00 (38)	39.47 (75)	28.42 (54)	12.11 (23)
Q10	You've learned physics with an AR Book.	26.32 (50)	43.68 (83)	21.58 (41)	8.42 (16)
Q11	You are interested in gaining physics learning by assisting with AR Books.	3.16 (6)	16.84 (32)	42.11 (80)	37.89 (72)

Table 2 shows students disagree that physics is one of the fun lessons. Subsequent statements regarding student parabolic motion materials agree that parabolic motion material is important to understand. However, they found the parabolic motion material difficult to understand. Then, The students agreed that the learning methods used by teachers were based on traditionally lectures rather than experimental methods. Teachers should

facilitate students by providing authentic problems during learning so that students can explore many concepts of Physics in relation to students' daily lives (Helmeyanto & Hariyono, 2021). However, even so students feel comfortable and happy with the learning methods that their teachers have.

Further related to CTS, based on Table 2 known that most students have done learning activities to improve CTS and have been frequently trained with CTS test questions. Also, students strongly agree that CTS are important to be taught in school. Related to ar book-assisted physics learning, most of them have never gotten AR book-assisted learning. And, in the future, students feel interested in getting physics learning assisted with AR book.

Interview Results of Interviews with Physics Teachers

This research is not only from the student's point of view, but also asks for the teacher's opinion on learning outcomes and learning models that teachers have done in school. Interviews are conducted to find out more details (Osborne et al., 2018) About learning physics in school. The results of the interview consisting of 7 questions, written into Table 3.

Table 3. Results of interviews with physics teachers regarding the implementation of physics lessons.

No.	Question	Answers
Q1	What are students' attitudes, motivations and interests regarding physics learning in school?	Grade of X students, is one of the students who get online learning almost entirely, so that the attitude, motivation and interest of students towards learning is still lacking, especially in the explanation of formulas and calculations. Numeracy skills are still lacking so that teachers have little difficulty providing understanding, especially calculations on physics learning.
Q2	Has the learning method used applied Merdeka Belajar to teach the concept of physics to students, especially on parabolic motion materials?	Not too really.
Q3	Are there any disadvantages or limitations of learning methods used to teach the concept of physics to students, especially in parabolic motion materials?	Nowadays Limitations, due to pandemic so that schools must continue to set a schedule between hybrid learning and distance learning. Thus, the explanation of physical matter is slightly less well conveyed.
Q4	Have CTS ever been specially trained to their primary students during teaching and learning activities in schools?	Ever, that is through the integration of physical phenomena into the learning of physics.
Q5	According to the Teacher, are CTS important? Give me a reason!	It is important, because in student life, whether in school, in learning, outside of learning, at home or anywhere else requires CTS.
Q6	According to The Teacher, how should efforts be made to improve CTS in students?	By giving you training questions.
Q7	Do you know or even teach with the assisted book AR? If you know or ever using it to learning process, give a response about AR Books!	Knowing, but never applying learning using the help of AR Books. Maybe that is quite interesting.

Table 3 Prove that the learning of physics in schools, especially in parabolic motion materials is still done traditionally and conventionally. There is no special treatment by the teacher to improve the student's CTS. Also, physics learning in schools in Surabaya still has not implemented many learning innovations. It also affects the attitude, motivation and interest of students towards learning physics in school. Much research has been done to understand the impact of applying PBL and AR, further combining the implementation of PBL with the integration of the latest technology trends such as AR, especially in physics learning. In order to strengthen the knowledge of researchers and look for shortcomings from previous research related to the implementation of AR-assisted PBL, researchers conducted an analysis of previous studies.

The analysis results of relevant researchs from last ten years (Dünser et al., 2012; Enyedy et al., 2012; Cai et al., 2016; Bakri, Ervina, et al., 2019; Bakri, Oktaviani Marsal, et al., 2019; Fidan & Tuncel, 2019; Wibowo et al., 2021; Gunawan et al., 2020; Hanid et al., 2020; Suprpto et al., 2020; Abdusselam & Karal, 2020; Faridi et al., 2021; Nandyansah et al., 2020; Wardani & Jatmiko, 2021; Cai et al., 2021; Zafeiropoulou et al., 2021; Putri et al., 2021; Wulandari et al., 2021) were poured into : (1) the application of the PBL model has a positive response to student attitudes, student learning outcomes, students' CTS, especially in Physics learning, and (2) On the other hand, the application of AR also shows positive results for learning. Older research find that AR has a medium impact on the students learning outcomes (Garzón & Acevedo, 2019). AR technology integrated of STEM education has brought some advantages to both teachers and also students as well (Mystakidis et al., 2021). Research find that the most AR implemented for STEM learning offered simulation, experiment or exploration activities (Ibáñez & Delgado-Kloos, 2018), not only in physics but also in other field like neurosurgery (Cho et al., 2020) and programming (Theodoropoulos & Lepouras, 2021). The greatest impact was achieved when the intervention used a collaborative pedagogical approach (Garzón et al., 2020). Then, the integration of AR into the PBL model is considered to be one of the effective learning innovations, add positive energy to students' feelings about learning physics, and explain better modeling of physical phenomena, especially in parabolic motion, than traditional learning.

Conclusion

Based on the research results of the data findings and analysis above, it can be concluded that the CTS of students at two schools in Surabaya are still low. The lowest critical thinking indicator is in "Interpretation" and the indicator that has the highest value is in "Inference". In gender mapping, male had lower average scores of CTS than female. This research also aims of surveys and tests with indicators of CTS, that these CTS must be trained to students by educators, especially on the subject of physical parabolic motion matter. In this research also found that schools still apply physics learning traditionally with conventional teaching materials and lecture methods still dominate learning. Students are interested in the integrated learning of AR books. In this study it is known that students' CTS can be influenced by appropriate methods in physics learning. Thus, researchers recognize the importance of innovation in learning models aimed at improving students' CTS. One endeavor that can be used to improve students' CTS is to implement the PBL model assisted ar book. Future researchs are expected to use more samples, indicators and types of physics substance.

Acknowledgement

Thank you to the lecturer and Universitas Negeri Surabaya who have facilitated this research and all parties involved both parents, friends, family, teachers and students at High School in Surabaya. Especially thanks for IA Education was founded this research.

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