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The physics problem solving skills profile of high school students in elasticity material and the implementation of augmented reality book-assisted PBL model

Kirana Aureola Arzak, Binar Kurnia Prahani*

Universitas Negeri Surabaya, Jl. Ketintang, Ketintang, Kec. Gayungan, Surabaya City, East Java 60231, Indonesia
e-mail: binarprahani@unesa.ac.id
* Corresponding Author.

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Abstract: The research aims to analyze the physics PSS profile of high school students and the implementation of the AR book-assisted PBL model as a consideration in the use of media and learning models to support the high school students' PSS improvement. This is preliminary descriptive research without hypothesis testing with 154 high school students as participants. Descriptive methods of qualitative approach is employed to analyze through questionnaires and tests of assessment about PSS. This study revealed that the students' PSS is still in the low level. This is evidenced by the students' results of low category with a score range within 0 to 50. This study also found that students' interest in learning physics with AR (Augmented Reality) books-assisted have improved their PSS. It is concluded that the learning methods, as well as learning media, can affect students' PSS
Keywords: elasticity; augmented reality; PBL; PSS

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Introduction

Education is a critical human need because education has the task of preparing human resources for nation-building. Education is currently expected to produce the resources of thinkers who can help in building social order (Zhao & Watterston, 2021), and professionally managed institutions produce knowledge as the citizens of the world to produce superior results (Renatovna, 2021). Advances in information and communication technology have affected human lifestyles in work and socializing (Boateng et al., 2021). In the beginning of the 21st century, technological advances have touched all fields, including education (Woldeab & Brothen, 2019). The 21st century is the beginning of globalization, where the human order of life begins to change towards a better era with the demands of making better and quality human resources accompanied and managed by professional institutions. Quality human resources are expected to be able to produce the latest breakthroughs, especially in the field of education. The 21st-century education prioritizes skills that can play an important and relevant role in the era by mastering and improving the skills and development of the quality of student learning by applying PBL. The PBL model has traits that indicate that learning is student-centered. A given problem refers to an exact problem by connecting small groups, and the teacher acts as a facilitator (Fauzi Bakri et al., 2021).

The PBL model is a learning approach where learners work on authentic (real) problems (Tong et al., 2021) so that learners can shape their knowledge, develop their high skills and inquiry, and increase their confidence (Sun & Zhuang, 2022). The PBL model is more than just effective for learning

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specific knowledge. The PBL model makes students able to change their experience (Kim, 2021) as a solution to solving new problems (Shofiyatul Masruro et al., 2021). Applying the PBL model is expected to train students' PSS through the problems presented. Students generally find it difficult to learn physics subjects because they are abstract and have many concepts, and it takes a lot of practice to master them (Cawthorne, 2021). Still, the PBL model can train students' PSS, especially in physics learning.

Physical concepts require high-level thinking and are often difficult for learners to understand (Gnesdilow & Puntambekar, 2022). Therefore, the presence of teachers is necessary to assist learners in facilitating everything they need, such as worksheets and learning models that are suitable for them (Permatasari et al., 2020). The implementation of the PBL model, especially for PSS, is seen as something urgent because, in everyday life, students are told to have PSS (Santuthi et al., 2020). Based on problems related to physical learning, the PBL model is a learning model needed to overcome difficulties in understanding physics subjects. There is an influence on the learning process after applying the PBL learning model to students' problem-solving abilities (Sun & Zhuang, 2022). This happens because in applying PBL models, students better understand, plan, solve problems according to plans, and recheck or interpret solutions (Yusri, 2018). The debriefing of PSS in the 21st century has been helpful as a benchmark for teachers to train students in PSS by improving the quality of learning to be implemented as well.

The PBL model do not only teaches students to solve problems but also shapes the character of students. Efforts in developing character education are essential to overcome moral and character crises and distinguish good and evil (Suherman, 2018). It also affects students' character, such as being friendly/communicative, where they are most dominantly affected by the educational environment. Friendly/communicative character is an attitude and action that encourages him to produce something useful stale society, recognize and respect the success of others, and actions that pay attention to the pleasure of talking to others (Kafarisa, 2018). Students' PSS through the PBL model needs to be improved from the basics considering that PSS plays an essential role in learning (Permatasari et al., 2020). PSS is an essential aspect because they help students to make wiser decisions. The problem-solving ability is defined as individuals' ability to use their thought processes in solving problems by gathering facts, analyzing information, compiling various solution alternatives, and choosing the most effective solution (Fitri et al., 2019).

On the other hand, PSS is the pinnacle of HOTS (Karimah et al., 2018). These skills combine creative and critical attitudes to be re-examined through the process (Manik, 2020). Teaching PSS related to authentic problems that are continuous with daily life is an essential task for educators in guiding students to maximize student success (Simarmata & Sirait, 2019). Therefore, applying PSS is considered necessary (Marwati & Mas'Ud, 2021).

In practicing students' PSS, teachers assess each student's PSS based on adjusted indicators (Dubuque & Kazemi, 2022). The ACCES indicator is used in measuring students' PSS. ACCES consists of Assen the problem (A), Creating a drawing (C), Conceptualizing the strategy (C), Execute the solution (E), and Scrutinize your result (S). Students identify problem principles in indicator A; students illustrate the problem into an image in indicator C; students formulate goals in indicator C; students use formulas and outline the steps of completion in indicator E students solve the problem correctly with the underlying reason on the indicator S. Innovations in learning activities (Siahaan et al., 2020), especially PSS, are expected to be able to support the learning needs of students in solving problems (Devy Alvionita et al., 2020). Problem-solving still needs to be further researched, and efforts are being made to practice the PSS, an innovation of this research. The purpose of the research is to analyze indicators used in PSS that are used as a measuring tool to find out the achievement of learning goals, analyze learning practices, including models and learning media, as well as physical materials that teachers can use to train high school students' PSS, in addition to tracking information about the causes of learners' difficulties in the process of solving physics problems. Students apply their knowledge (Nafsika & Soeteja, 2021) and skills to achieve problem-solving accompanied (Setyarini et al., 2021) by the teacher. To support students' skills in physics subjects, the augmented reality book-assisted PBL model can be applied as a medium of learning.

Augmented reality in the world of education has not been implemented (Roopa et al., 2020) and applied as a supporting medium for interactive education in schools (Liono et al., 2021) because there are no educational agencies that apply as a mandatory media that serves as a means of learning (Al-Hassan et al., 2020). Augmented reality technology has advantages (Mystakidis et al., 2022), especially in the field of education, namely as a medium of guidance and support in the learning process that maximizes students' understanding in absorbing the material provided (Çetin & Türkan, 2022). Based on the background that has been presented, the above research aims to analyze students' PSS as a consideration in the use of media and learning models that support the improvement of high school students' PSS.

Method

This research employed descriptive and qualitative approaches to analyze a phenomenon that is studied through the support of literature studies to strengthen the results of research obtained in making conclusions. The description of statistics and data decryption is based on student questionnaire answers (Santiani et al., 2020). The purpose of descriptive research is to describe a particular circumstance or condition (Safarati & Rahma, 2020). The stages of descriptive methods, according to (Aulyana & Fauzi, 2019), are as follows; (1) planning, (2) designing, (3) developing instruments, (4) collecting data, and (5) describing the data that has been obtained.

This study applied the ACCES method as a benchmark for physics solving skills in high school students. Research instruments used in this study include: 1) PSS tests of elasticity material, 2) student response questionnaires, 3) teacher interview sheets 4) and student interview sheets. Survey research provides questions to some respondents about characteristics and to understand the relationship among variables or factors, as well as provide informational benefits for evaluating educational programs (Suprapto, 2019). The absorption of media and learning models capable of improving physics problem-solving skills in students can be considered through the results of this study.

The study was conducted at one school in Surabaya and Sidoarjo city in February 2022, with 154 11^{th}-grade high school students as respondents. Purposive sampling techniques were used in this study. The data collection was done through distributing questionnaires in the form of google form links (Novianti & Syarkowi, 2021) and conducting interviews with physics subjects teachers. Qualitative descriptive techniques are used as data analysis techniques in this study to describe the situation factually and concretely. The methods used by researchers are briefly described in Figure 1.

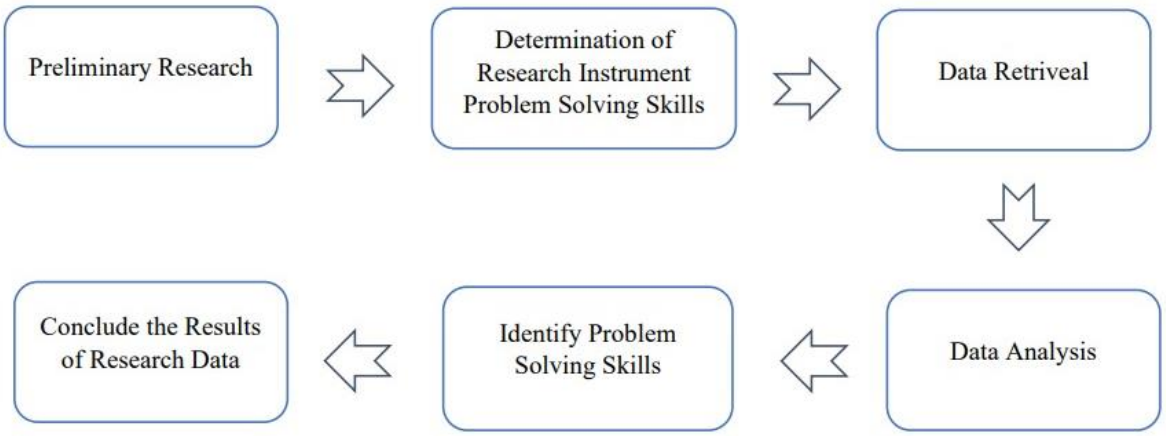

Figure 1. Research Methods

Results and Discussion

The PSS assessment sheet presented to high school students consists of 5 questions with each problem that has applied the PSS indicator in the form of ACCES where students are asked to solve the problem following the instructions listed at the top of the test sheet. In the test implementation, students are given a time limit for their work. They are not allowed to see other student-owned work,

so it is expected that the results obtained can be used as a benchmark for students' PSS related to elasticity material. In addition to filling out a PSS assessment sheet, students must also fill out student response questionnaires related to physics learning in school.

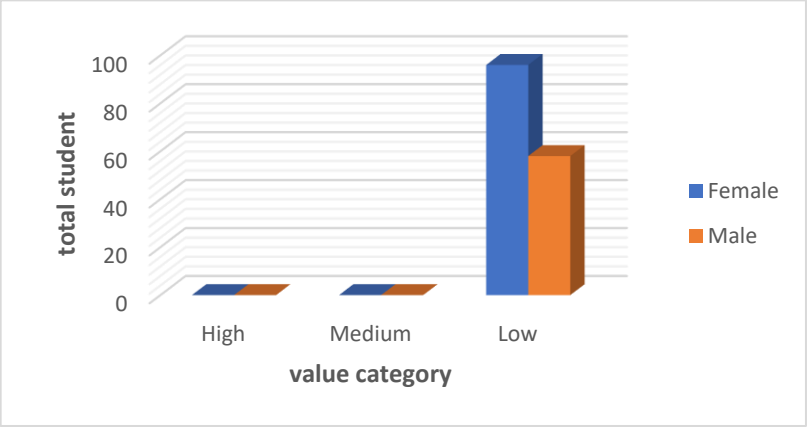

Figure 2. Link student numbers to ACCES assessment indicators

Figure 2 shows the assessment results of students' PSS on elasticity material equipped with ACCES assessment indicators. The problem in this assessment has a maximum score of 20 and a problem of 5 points. The maximum score is 100, with each indicator on each question worth 4. The number of students who obtained assessment results was classified in the low (0-50), moderate (51-75), and high (76-100) categories. In the three categories shown, 96 female and 58 male students belonged to the low category. Through the results of the PSS assessment at two schools, student assessment results do not fall into the medium and high categories, so 154 students fall into the low category. Through the process of analyzing students' answers in solving problems that have been done, it is known that high school students still have difficulty in solving problems equipped with ACCES indicators as follows:

(A)– Assen the problem (Identifying problem principles)

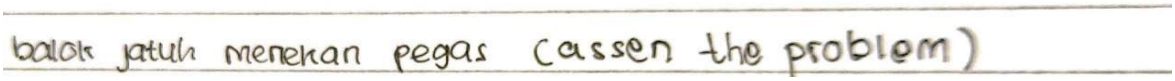

Figure 3. Student answers on indicator "A"

Assen problem indicators ask students to identify the principles of the problem in a given problem. Based on Figure 3, it can be seen that students answered questions on the assen indicator question with "*the falling block presses on the spring* ."Through these answers, it is known that it does not meet the answer criteria used by students, where the principles of questions relate to maximum acceleration, so the student's answers are said to have not met the indicators requested.

(C)- Create a drawing (Translating words into illustrations as clues in problem-solving)

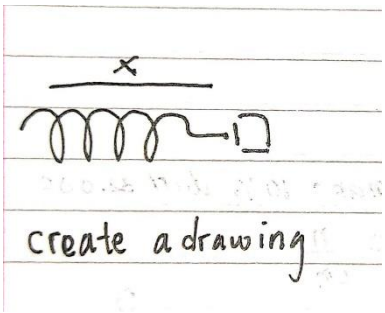

Figure 4. Student answers on indicator "C"

In the indicator *create a drawing*, students were asked to translate words into an illustration that made as a clue in problem-solving. In Figure 4**,** students were asked to illustrate a spring suspended from the elevator ceiling with a load of 40 grams. Still, the student's answer sheet showed the student needed to be able to illustrate precisely based on the given problem.

(C)-Conceptualize the strategy (formulate goals)

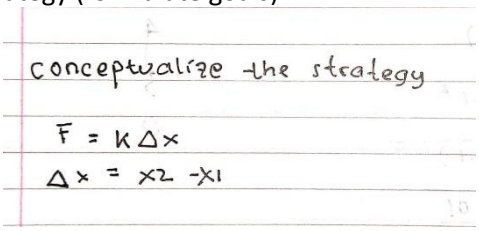

Figure 5. Student answers on indicator "C"

The conceptualized strategy indicator asks students to formulate the goals to solve the given problem. In Figure 5, students were asked to formulate a goal for the spring addition problem. From the answer, it is known that students are used to applying calculations directly with the formula rather than describing the steps used. There needs to be more clarity in the work of the problem.

(E)- Execute the solution (apply formulas to solve problems)

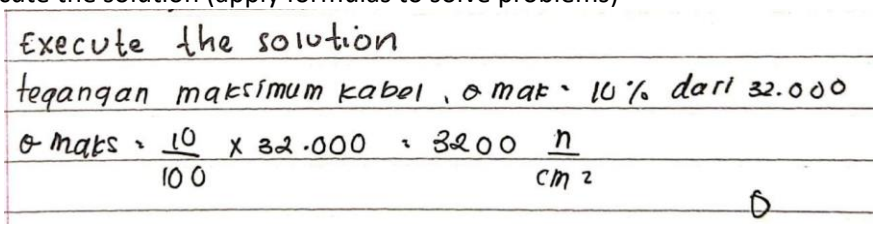

Figure 6. Student answers on indicator "E"

Figure 6 indicator executes the solution, and students are asked to apply a formula to know the maximum acceleration of an elevator. Most students needed help with applying problem variables in applying the formula so that in the calculation process, the results given did not match the requested problem bill.

(S)- Scrutinize your result (Looking back at your answer)

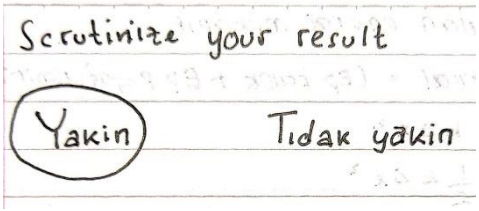

Figure 7. Student answers on indicator "S"

The scrutinize your result indicator asks students to show confidence in the answers given accompanied by reasons. However, in Figure 7, the majority of students did not give an apparent reason why students feel confident in the answers given that show that students still did not understand what kind of settlement should be spelled out when they were asked to describe the answers written.

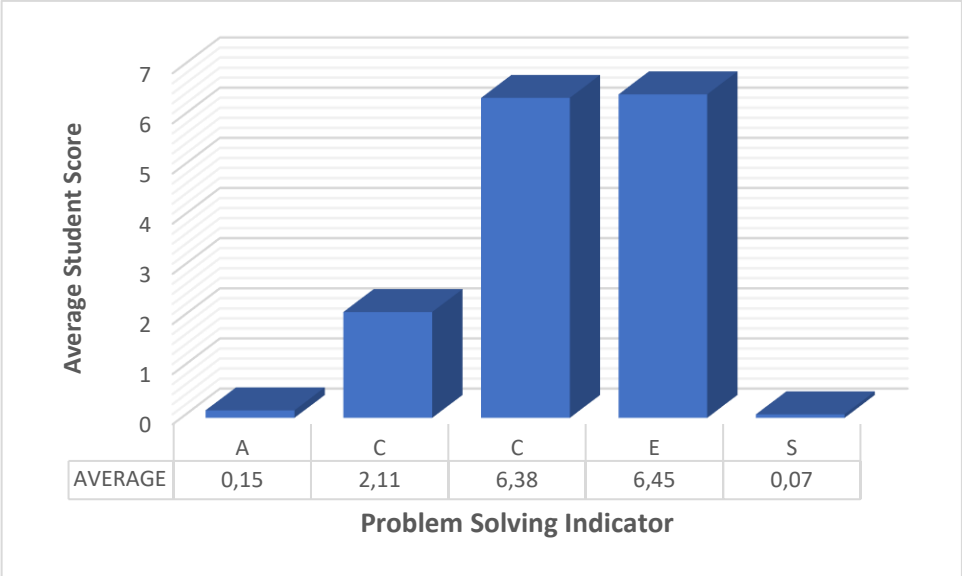

Figure 8. Student's average scores on each indicator of PSS

Figure 8 shows that the conceptualize the strategy (C) and execute the solution (E) indicators are the highest value indicators with 154 respondents. This indicates that students tend to solve a given physics problem using a formula directly without identifying the principle and outlining the problem-solving steps per the given indicators. The scrutinize your result (S) indicator and the assen the problem (A) indicator are the indicators with the lowest average values. It can be concluded that students still need to learn to identify problem principles and show confidence in solving problems, evidenced by supporting reasons.

Student Response Questionnaire

It is provided through Google Form on 233 high school students in class XI related to the student learning experience in physics learning to find out student responses related to physics learning based on PSS and teacher delivery when learning activity. Students are asked to fill out a questionnaire containing ten statements with strongly agreed (SA), agree (A), disagree (D), and strongly disagree (SD) levels. The results of the student response questionnaire are expressed in the form of percentages as follows:

Table 1. Student Response Questionnaire Results

Statement	Percentage (%) and Number of Students			
	SA	A	D	SD
Physics is a fun subject.	5,2 (12)	42,1 (98)	42,9 (100)	23,9 (23)
Elasticity material is elusive.	11,2 (26)	45,5 (106)	36,1 (84)	7,3 (17)
Elasticity material is important to understand.	27,9 (65)	44,2 (103)	24,9 (58)	3 (7)
Have undertaken learning to practice PSS in physics learning.	14,6 (34)	44,2 (103)	30,9 (72)	10,3 (24)
Difficulty in carrying out learning to practice PSS.	12,9 (30)	50,6 (118)	26,2 (61)	10,3 (24)
Difficulty in working on problems to practice PSS.	16,3 (38)	42,1 (98)	33 (77)	8,6 (20)
The methods of physics learning that have been applied by teachers today are easy to understand.	13,7 (32)	42,1 (98)	33,5 (78)	10,7 (25)

Statement	Percentage (%) and Number of Students			
	SA	A	D	SD
Lecture methods are more often used by teachers than learning methods with simulations / learning media that support.	19,7 (46)	34,2 (80)	36,9 (86)	9 (21)
Have conducted AR book-assisted learning activities (Augmented Reality) in physics learning.	5,2 (12)	20,6 (48)	38,2 (89)	36,1 (84)
Interested in AR (Augmented Reality) book-assisted learning in physics learning.	16,7 (39)	43,3 (101)	30,5 (71)	9,4 (22)

Teacher and Student Interview

Through interview activities with teachers and students, it can be identified that the teachers have applied PSS in physics learning. According to teachers, PSS plays an essential role in the learning process of teaching students, especially in the field of physics. In the implementation, teachers and students state that there are several obstacles in the implementation of learning that apply problem-solving skills caused by the variety of student learning styles that need to be aligned based on the criteria of each student's learning ability and the student's familiarity with previous learning methods, so that adaptation is needed in their application. In its implementation, students tend to solve physics problems directly without going through the identification of physical concepts first in contrast to PSS where several stages are needed to solve them so that students can understand the entire concept of physics provided. Teachers take longer time to set the students to implement problem-solving skills in physics learning. Some time ago, the school imposed an online learning system due to the covid-19 pandemic (Wiradinata et al., 2021). Students undertake learning activities through Google Classroom (Rusmansyah et al., 2021) and Microsoft Teams. The implementation of online learning inhibits teachers from applying learning to train PSS in students, so the application of PSS still needs to be improved. Teachers and students have never applied physics learning-aided AR (Augmented Reality) books as a means of support in physics learning activities.

Many studies have examined the implementation of learning models, especially PBL and AR book-assisted learning models. In this study, an analysis of research articles in the span of 2018-2022 discussed the implementation of PBL models and learning that utilizes AR technology to increase knowledge and reference researchers in observing the shortcomings and advantages of previous research. Table 2 contains the analysis results from various studies that discuss the implementation of PBL learning models and AR technology.

Table 2. Relevant Research

Author	Research Objective	Research Results
(Suryani et al., 2020)	Indicates students' PSS about social arithmetic through models PBL.	Through assessment guidelines of students' problem-solving abilities, it was found that students' mathematical PSS through the PBL model was relatively good.
(Fitriyani et al., 2019)	Conduct collaborative LKS influence analysis on PBL learning models on high school students' PSS on parabolic motion materials.	The application of collaborative LKS to the PBL model positively improves high school students' PSS in parabolic motion materials.
(Astra et al., 2019)a	Measure the effectiveness of using the PBL model to improve students' critical thinking and problem-solving on temperature and heat material.	Through the results of tests in cycles I to cycle III obtained by students, it is known that students' critical thinking and PSS increase.
(Ramli et al., 2021)	Develop website-based e-books by applying the PBL model to student learning on fluid materials.	Through some validation, e-books have very feasible and practical criteria for improving student PSS through the PBL model.
(Mahfud et al., 2020)	Measure the effectiveness of the PBL model through e-Learning in high school students.	It is known that using E-Learning in the PBL model effectively improves the learning outcomes of high school students.

Author	Research Objective	Research Results
(Nirwana et al., 2021)	Analyze the impact of PSS instruments applied in Madrasah Tsanawiyah on the learning material of vibrations, waves, and sounds.	Demonstrate that all instrument tests are highly valid and declared fit for use.
(Nashar et al., 2021)	This research aims to analyze the effect of the PBL model on student critical improvement and problem-solving.	The PBL model improves students' critical thinking and PSS more effectively than interactive learning.
(Saputra et al., 2020)	Measure the effectiveness of the PhET-assisted PBL model on student learning independence.	Applying the PhET-assisted PBL model ensures independent students are categorized as successful and feasible.
(F. Bakri et al., 2021)	Practice the PSS of high school students aided by TPACK physics textbooks.	Applying TPACK physics textbooks is otherwise feasible in practicing PSS for high school students.
(Guntur et al., 2020)	Lays out the relationships of AR technology in improving problem-solving and spatial skills through the study of theory.	Positive results are obtained in applying AR technology to problem-solving and spatial skills.
(Sunarti & Septiana, 2020)	Analyze influences PBL with Gallery Walk strategy to improve communication and creativity in physics learning.	Demonstrate that applying the PBL model accompanied by the Gallery Walk strategy can improve students' communication skills and creativity.
(Fidan & Tuncel, 2018)	Conducted investigations through SSCI-indexed journals between 2012-2017 into specific features of AR technology.	The increasing number of AR technology research in 2014-2017 is mainly in science.
(Wulandari et al., 2021)	The study's goal was to reveal augmented reality's influence on physics learning models.	The results showed that the decision to integrate augmented reality technology in the learning model was able to support students' learning processes and outcomes.
(Sulisworo et al., 2021)	Review PSS skills partly from HOTS capabilities through an open source and without open source assisted PBL model.	Experimental classes applying open-source-assisted PBL models show differences with control classes without open learning resources.
(Fidan & Tuncel, 2019)	Investigate the effect of AR technology-assisted PBL models on learning achievement and attitudes toward physics subjects as part of an educational IPA.	The results of the experiments showed that applying AR technology in the PBL model improved students' learning achievement and political attitude to physics.

Table 2 shows positive responses to implementing PBL learning and learning models that integrate AR technology (Fidan & Tuncel, 2019). The results shows that PBL models significantly affect high school students physics PSS, particularly on Hooke's law and elasticity (Susanto, 2019). In research that applies augmented reality integrated learning modules qualified with good quality and deserves to be used as a supporting module in learning and influential in improving student learning achievement in physics subjects compared to conventional learning. It implies that the implementation of PBL model with AR technology on learning is considered essential to improve students' PSS since this shows innovation in teaching and learning activities.

Conclusion

Based on the research analysis, it was concluded that students' PSS by applying ACCES indicators to two schools in Surabaya are still classified as low. Through surveys and tests of assessment of elasticity material PSS in the gender category, with the number of 96 female students and 58 male students have a relatively low average PSS score. The scrutinize (S) your result indicator and the assen (A) the problem indicator are the indicators with the lowest average values. In this study, students felt they were bothered to solve problems with access indicators. This is because students tend to solve

physics problems without identifying and describing the understanding of concepts and focusing on completing them through formulas and calculations, so there are often misconceptions appeared. In 2 schools that conducted research, it is known that physics learning still applies conventional methods with teachers giving material in lectures. This study found students' interest in learning physics assisted by AR (Augmented Reality) books. Learning methods, as well as learning media, are known to influence students' PSS. Therefore innovations in learning models play an essential role in improving students' problem-solving skills in physical learning. Applying appropriate models accompanied by creative learning media can improve students' PSS. Efforts that can be applied based on this research is the implementation of the AR book-assisted PBL learning model ia considered appropriate.

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