



## Application of Formative Assessment to Analyze Students' Problem-Solving Skills

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### Abstract

The purpose of this study was to investigate students' problem-solving abilities using parabolic motion material through the use of formative assessments. The research method adopted is a survey combined with a qualitative descriptive analysis. This study was conducted at SMA Muhammadiyah X Surabaya with 123 students as respondents, 65 of whom were male and 58 of whom were female. On the parabolic motion material, the question instrument is utilized to examine the profile of problem-solving abilities. The results indicated that the problem-solving skill profile of X MIPA students at SMAM X Surabaya was low, with 49.94% falling into the inadequate category. Female students have a stronger capacity for problem-solving than male students. These findings demonstrate that students each possess unique strengths and advantages. Formative assessment has a beneficial effect on students' problem-solving abilities when they are exposed to parabolic motion content.

**Keywords:** Formative Assessment, Physics, Problem Solving Ability

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## INTRODUCTION

Education is vital to the generational growth of a nation. Today's school system heavily relies on the development of 4C skills (Communication, Collaboration, Critical Thinking, and Creativity) (Rosyad et al., 2020). Problem-solving competencies are a crucial component of 21st-century education (Care et al., 2016). The ability to solve problems could be characterized by the ability to examine and solve a complex question (Griffin, 2017). Problem-solving abilities enable students' to maximize their knowledge, abilities, and confidence when it comes to resolving challenges in their immediate area (Rahmana et al., 2021). Physics is one of the disciplines in school that can help students develop problem-solving skills (Indrawati et al., 2021).

Physics education is a process of observation and experimentation (Mashuri et al., 2021). Physics lessons play a critical role in a variety of natural events that occur in everyday life; this is strongly tied to technology and the environment (Princess, 2017). One of the indicators of successful physics learning is the capacity to comprehend concepts, talents, vitality, and problem-solving abilities (Alieffia et al., 2018a). Students frequently make the error of executing mathematical equations without consideration for the proper ideas and understandings (Docktor et al., 2015). Indeed, solving issues in physics classes requires an understanding of the nature of concepts and principles, as well as the use of qualitative analysis to constrain difficulties through the separation of necessary concepts (Docktor et al., 2016).

Learners in Indonesia still have a limited capacity for problem-solving (Alvinda et al., 2021). This is based on research indicating that learners' ability to solve the physics of

parabolic motion matter is still quite low. Majority of students make errors because to the nonconformity of their piety in answering the parabolic motion issues (Maharani & Kartini, 2019). According to research findings, the problem-solving abilities of parabolic motion materials are so poor that it is difficult for learners to become adept at solving a particular problem (Hartanti et al., 2021). According to earlier studies, learners have trouble solving problems and comprehending concepts in parabolic motion. The harmonious research indicates that students' ability to think critically about parabolic movement problems is still relatively low. Through appropriate assessment, learners' problem-solving abilities can be developed (Nur et al., 2020)

Assessment is the goal of learning, and it is done in a systematic and comprehensive manner with the goal of supervising and enhancing the learning process (General et al., 2017). The learning and assessment processes are inextricably linked in establishing the technique that teachers use to deliver learning information to students (Utami, 2016). Assessments given by teachers while the learning process takes place can cause some problems such as inening assessments that can hinder the conceptual understanding of learners. (López-Lozano et al., 2018) This statement also supported by the opinion (McCarthy, 2017) that teachers' formative assessments are used solely to determine if learners have mastered their content, with no feedback supplied to learners, so that learners are unaware of material that has not been grasped.

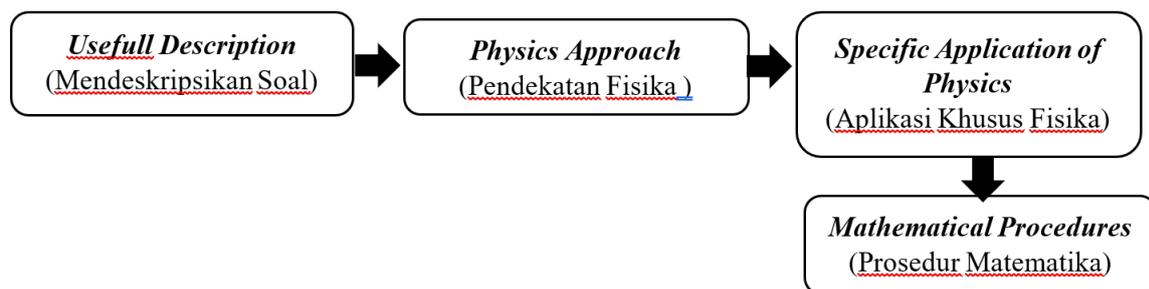
Formative assessment is an assessment that can support learners in solving their own problems (Amiroh & Kusairi, 2020). The purpose of formative assessment is to motivate and optimize learners in carrying out the learning process to achieve mutual understanding. This is in accordance with the opinion of formative assessment can provide benefits and feedback for teachers and learners in the learning process. Giving feedback for students can provide encouragement to learn, while for teachers can be used to design the next learning better (Owen, 2016).

Until now, formative assessment was adopted by several authors to identify students' knowledge, such as according to (Hindriyani et al., n.d.) formative assessment showed a strong influence and positive impact on the problem-solving ability of DC circuits; (Lukitawanti et al., 2020) problem-solving ability on elasticity and Hooke's law material showed an increase; (Rosyad et al., 2020) formative assessment has a positive impact on student's motivation and learning outcomes on elasticity materials; (Nur et al., 2020) learning accompanied by formative assessment can provide an increase in conceptual mastery and motivation to learn legal material. Similar research without formative assessment related to problem-solving ability analysis was also adopted by several authors such as (Pratama et al., 2017; Feribertus Nikat & Latifah, 2017; Hanif Afiat et al., n.d.) work and energy materials; (Purnamasari et al., 2017) static fluid material; (Alvinda et al., 2021) material for parabolic motion. However, the analysis of problem-solving ability profiles with formative assessments reviewed by gender on parabolic motion material has never been reported. This study focuses on the differentiating factors of thinking ability and determining problem-solving taken by students. Although men and women have different characteristics, teachers must provide students with equal opportunities and motivation in learning, so that students do not feel different in the learning process. Formative assessment can help teachers identify learning according to the needs of students so that they can adapt instruction or feedback to meet those needs. It is hoped that the problem-solving ability profile analysis activity can help teachers identify problems faced by male and female students in solving physics problems with parabolic motion material.

Based on the description of previous problems, research is needed using formative assessments during the learning process with the aim of analyzing learners' problem-solving skills in parabolic motion materials using indicators and problem-solving rubrics developed by (Docktor et al. 2016).

## METHOD

This study employed survey techniques in conjunction with tools for qualitative descriptive analysis. The survey enrolled 123 respondents, 65 from the men's class and 58 from the women's class, at Muhammadiyah X Surabaya High School. The instrument is used to develop problem-solving abilities of up to five soals in the form of esai in material with parabolic motion. The research follows a three-stage procedure: (1) the preparatory stage, which includes the compilation of instruments in the form of problems in line with problem-solving indicators as data gathering approaches. (2) implementation stages, in which learners' problem-solving abilities are profiled using instruments evaluated by two professional lecturers from Surabaya State University and physics teachers from Muhammadiyah High School X Surabaya, and (3) Evaluation stage. Problem solving steps according to Docktor can be shown in Figure 1.



**Figure 1.** Problem solving procedures (Docktor et al., 2016).

Students' problem-solving abilities are classified according to each sign of docktor problem-solving phases, as shown in Table 1. The purpose of this is to analyze and describe the abilities and accomplishments of learners while they work on docktor problem solving type challenges.

**Table 1.** Problem-solving indicators (Docktor et al., 2016).

Indicators	Descriptor
Describing a problem	Learners are able to comprehend the challenge by depicting it visually and recording the amount of physics that is known and requested.
Approach to Physics	Learners can determine problem-solving solutions using concepts, equations and principles of physics.
Special Applications of Physics	The values of known quantities can be substituted by learners for established concepts, equations, and scientific principles.
Mathematical Procedure	Learners are able to implement solutions that have been made before using selected physical equations and mathematical calculations mathematically.
Suitability of Answers	Learners examine all problem solving and review each problem-solving step clearly, focused and logically resolved.

Here is the calculation of the percentage of the final value of the learner's problem-solving skills (Hariri Mustofa & Rusdiana, 2016).

$$NA = \frac{N_i}{N_{max}} \times 100\% \dots (1)$$

Information:

NA = percentage of the final value.

$N_i$  = the value obtained by learners on one problem-solving indicator

$N_{max}$  = maximum value on one troubleshooting indicator

$n$  = number of learners

The percentage categories of problem-solving test results according to (Docktor et al., 2016) showed in Table 2.

**Table 2.** Percentage category of troubleshooting ability test results (Alieffia et al., 2018)

Percentage (%)	Category
0-40	Very unsatisfactory
41-55	Unsatisfactory
56-70	Quite satisfying
71-85	Satisfying
86-100	Very satisfying

## RESULTS AND DISCUSSION

Parabolic motion according to (Halliday & Resnick, 2010) is the motion of objects whose trajectory is affected by gravity in such a way that the trajectory of a parabolic object with a combination of irregular straight motion and straight motion changes in a predictable manner. The motion of a straight item is analyzed by decomposing the x-axis (horizontal motion), whereas the motion of an irregular object is analyzed by decomposing the y-axis (vertical motion). According to the findings of research, the majority of students who have been unable to handle problems involving parabolic motion material. The ability of learners to solve problems can be determined by their responses to the parabolic motion material test, which consists of five descriptive questions. The assessment of learners' responses is based on a rubric produced by the process of learners solving issues, which is measured using five indicators with a range of 0-5 for each indication. (Docktor et al., 2016).

Sebuah meriam menembakkan sebutir peluru pada sudut  $45^\circ$  terhadap garis horizontal. Kemudian meriam tersebut membentuk lintasan parabola di atas tanah mencapai jarak sejauh 20 m dalam waktu 2 detik. Tentukan kecepatan peluru saat ditembakkan di atas tanah!

**Figure 2.** One of the research's instruments number 3

Diket :  
 $\theta = 45^\circ$   
 $x_{\max} = 20 \text{ m}$   
 $t = 2 \text{ detik}$   
 $v_0 = ?$

$$x = \frac{v_0^2 \sin 2\theta}{g}$$

$$20 = \frac{v_0^2 \sin 2(45^\circ)}{10}$$

$$200 = v_0^2 \sin 90$$

$$200 = v_0^2 \cdot 1$$

$$v_0^2 = \frac{200}{1} \Rightarrow v_0 = \sqrt{200} = 10\sqrt{2} \text{ m/s}$$

Kecepatan peluru saat ditembakkan di atas tanah adalah  $10\sqrt{2} \text{ m/s}$ .

**Figure 3.** One of the students answer number 3

The motion of objects whose trajectory is affected by gravity in such a way that the trajectory of a parabolic object with a combination of irregular straight motion and straight motion changes in a predictable manner. The motion of a straight item is analyzed by decomposing the x-axis (horizontal motion), whereas the motion of an irregular object is analyzed by decomposing the y-axis (vertical motion). According to the findings of research, the majority of students who have been unable to handle problems involving parabolic

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Andi adalah pemain basket. Dia berdiri pada lapangan basket sejauh 10 m dari posisi ring basket. Tinggi andi adalah 2 m, dan tinggi ring basket adalah 3,05 m. Andi sedang berlatih melakukan lemparan jarak jauh dari posisi tersebut. Andi berlatih melemparkan bola basket dengan sudut  $40^\circ$  dengan bidang horizontal dan bola tepat lurus ketinggian kepala andi. Tentukan kecepatan lemparan bola agar bola tepat masuk ke lubang ring basket jika nilai  $\cos 60^\circ = 0,766$ ;  $\sin 40^\circ = 0,643$ ;  $\tan 40^\circ = 0,839$ !

**Figure 1.** One of the research's instruments number 4

4)  $V_y^2 = v^2 \sin^2 30 - 2gh$   
 $0 = 0,25 v^2 - 2 \times 10 \times 1$   
 $0,25 v^2 = 20$   
 $v^2 = 80$   
 $v = 4\sqrt{5} \text{ m/s}$

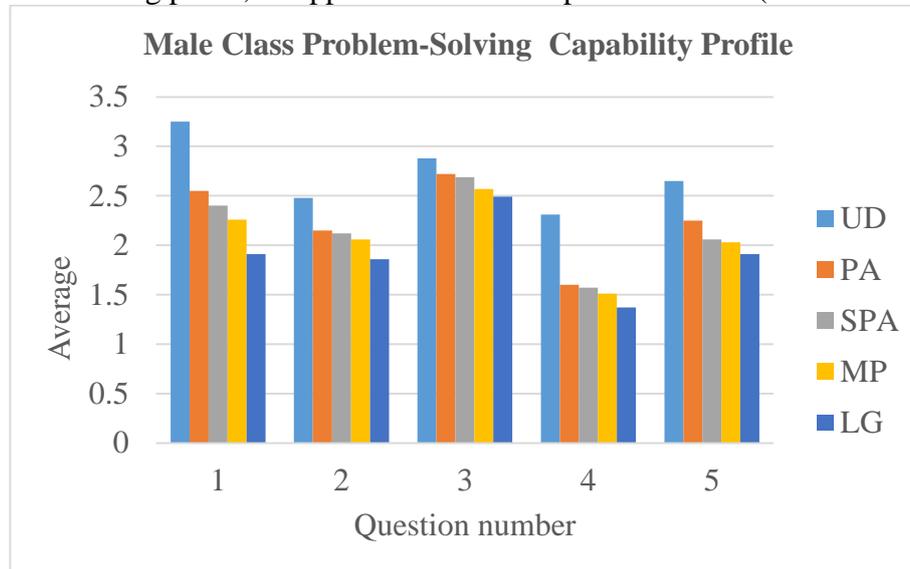
**Figure 5.** One of the students answer number 4

Figure 4 is the answer to the fourth question. Learners are tasked with calculating the speed of a ball whose initial height is greater than zero ( $y_0 > 0$ ) and whose ultimate height is also greater than zero ( $y > 0$ ). The indication learners receive a score of 0 since they are unable to comprehend and appropriately express the situation. There is no known quantity of physics, questions, or imagery that adequately express the issue. The PA indicator receives a score of 1 because learners do not comprehend the problem and rely on guesswork to answer the existing formula or physical equation. The equation utilized does not correspond to the problem at hand. The learner's SPA indication likewise receives a score of 1, as learners are capable of implementing known physical values in physical equations, but not everything is correct, and errors occur. Learners receive a score of 1 for MP indications because they run physical equations with mathematical calculations, but they are not true (Feribertus Nikat & Latifah, 2017). While the LP indicator of learners gets a score of 0 because there is no conformity of answers to problem problems.

### Male Class Problem-Solving Capability Profile

According to the findings of the research, the percentage of students in the parabolic motion materials class X MIPA SMAM X Surabaya men's class with a problem-solving skill of 44.52 percent falls into the category of less satisfactory. The highest indicator of men's class problem-solving ability in parabolic motion material is UD (Useful Description), with a percentage of 54.28 percent in the unsatisfactory category, while the lowest average is LG (Logical Progression), with a percentage of 38.16 percent in the very unsatisfactory category. The Figure 6 and Table 3 provide additional information. While the Ud (Useful Description) indicator has the greatest average, not all students in the men's class are capable of comprehending the problem by the use of graphics and writing down the amount of physics known and requested (Ayumniyya et al., 2021). This demonstrates that learners were unable to filter out critical information from a presented challenge (Qamar Rachmawati et al., 2022).

Some other factors that cause a lack of problem-solving skills are learners do not double check the answers obtained because they cannot solve the problem given. If noted, the average acquisition of problem solving indicators shows a decrease in data in each stage of the indicator. This indicates that learners are struggling in the early stages. (Dyah et al., 2020) then, as the problem becomes more complex, the learners solve it at the subsequent level. The problem item with the greatest troubleshooting indicator is number three. This indicates that the student in the men's class is capable of resolving the problem on problem item 3 using the whole problem solving phase, as opposed to the other problem items (Saami et al., 2021).



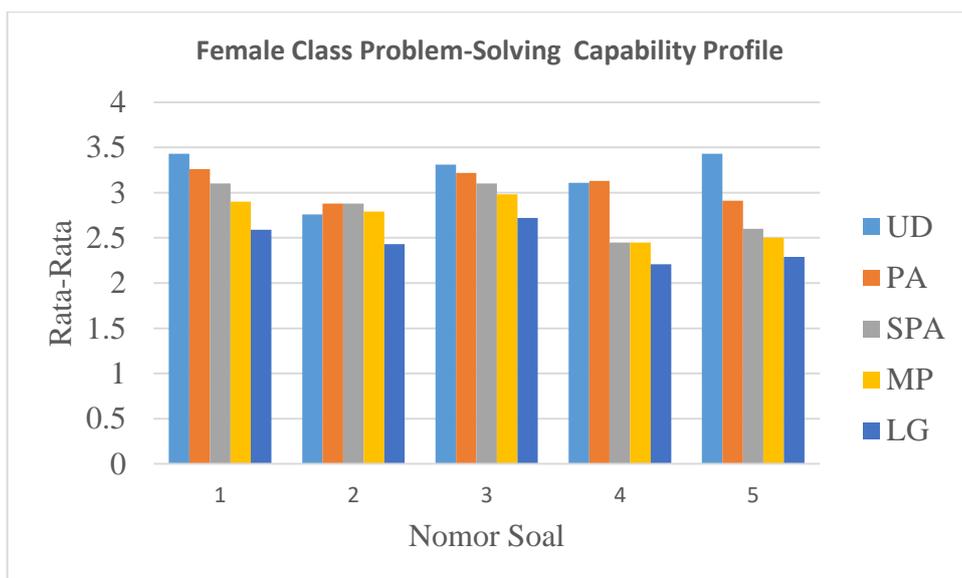
**Figure 6.** Average profile of male class-solving ability

**Table 3.** Percentage of men's class troubleshooting indicators

No.	Indicators	Percentage(%)	Category
1	UD ( <i>Usefull Description</i> )	54.28	Unsatisfactory
2	PA ( <i>Physics Approach</i> )	45.08	Unsatisfactory
3	SPA ( <i>Specific Application of Physics</i> )	43.36	Unsatisfactory
4	MP ( <i>Mathematical Procedures</i> )	41.72	Unsatisfactory
5	LP ( <i>Logical Progression</i> )	38.16	Very unsatisfactory
	Average	44.52	Unsatisfactory

### Female Class Problem-Solving Capability Profile

According to the findings of the research, the percentage of students with problem-solving skills in the parabolic motion topic class X MIPA SMAM X Surabaya women's class is pretty satisfactory at 57.14 percent. The indicator with the highest average for women's class problem-solving abilities in parabolic motion material is UD (Useful Description), which has a percentage of 64.16 percent in the category of quite satisfactory, while the indicator with the lowest average has a percentage of 48.96 percent in the category of unsatisfactory. Figure 7 and Table 4 contain detailed information. This explains why students struggle with understanding the position of objects on the x and y axes. When tackling difficulties, indicated learners endure anxiety and make educated guesses. Thus, the process through which learners solve problems becomes plainly unorganized (Mashuri et al., 2021). However, the UD indication is lower than the PA and SPA values for issue items 2 and 4. This is because learners frequently lack the ability to illustrate the problem, lowering their overall score. (Hanif Afiat et al., 2020). Overall, female learners experience the same problems as male learners.



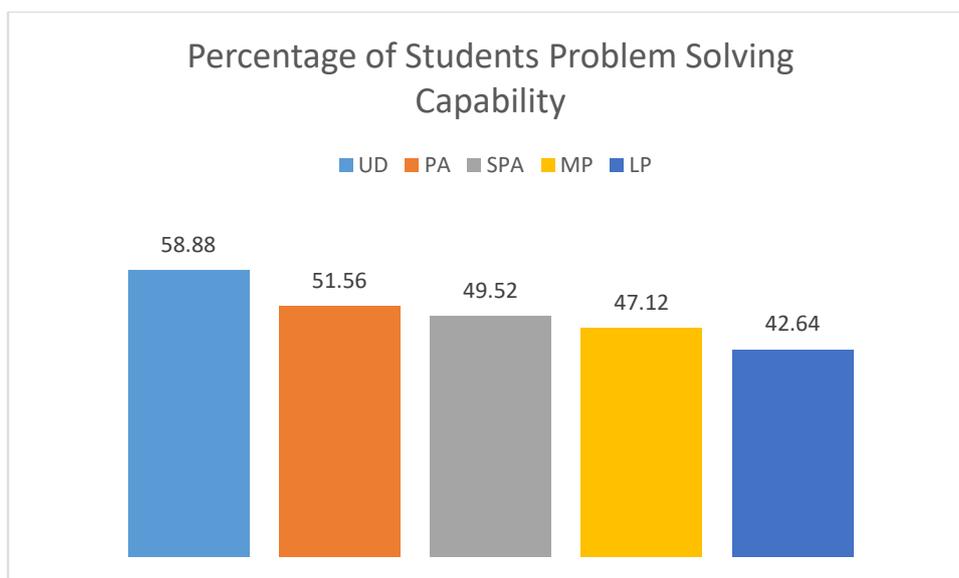
Figur 7. Average profile of female class problem solving abilities

Table 4. Percentage of women's class problem solving indicators

No.	Indicators	Percentage(%)	Category
1	UD ( <i>Usefull Description</i> )	64.16	Quite satisfying
2	PA ( <i>Physics Approach</i> )	61.60	Quite satisfying
3	SPA ( <i>Specific Application of Physics</i> )	56.52	Quite satisfying
4	MP ( <i>Mathematical Procedures</i> )	54.48	Unsatisfactory
5	LP ( <i>Logical Progression</i> )	48.96	Unsatisfactory
Average - Average		57.14	Quite satisfying

According to the findings of the research, the percentage of students with problem-solving skills in the parabolic motion topic class X MIPA SMAM X Surabaya women's class is pretty satisfactory at 57.14 percent. The indicator with the highest average for women's class problem-solving abilities in parabolic motion material is UD (Useful Description), which has a percentage of 64.16 percent in the category of quite satisfactory, while the indicator with the lowest average has a percentage of 48.96 percent in the category of unsatisfactory. Figure 7 and Table 4 contain detailed information. This explains why students struggle with understanding the position of objects on the x and y axes. When tackling difficulties, indicated learners endure anxiety and make educated guesses. Thus, the process through which learners solve problems becomes plainly unorganized (Mashuri et al., 2021). However, the UD indication is lower than the PA and SPA values for issue items 2 and 4. This is because learners frequently lack the ability to illustrate the problem, lowering their overall score.(Hanif Afiat et al., 2020). Overall, female learners experience the same problems as male learners.

Based on the results of the data above it is known that X MIPA learners at Muhammdiyah X Surabaya High School have difficulty in solving questions based on problem solving skills. This is indicated by an average percentage score of learners' problem-solving ability of 49.94% in the less satisfactory theory. This is because learners are still not able to answer questions based on indicators of problem-solving skills. The questions given are the higher order thinking skills (HOTS) category so that learners feel that the problems that have been given are too difficult to solve (Pratama et al., 2017). However, on some of these indicators, there are more prominent results This is explained in Figure 8.



**Figure 8.** Percentage of Problem Solving Capability Level X MIPA SMAM X Surabaya

**Table 5.** Percentage of problem-solving capability level X MIPA SMAM X Surabaya

No.	Indicators	Percentage (%)	Category
1	UD ( <i>Usefull Description</i> )	58.88	Quite satisfying
2	PA ( <i>Physics Approach</i> )	51.56	Unsatisfactory
3	SPA ( <i>Specific Application of Physics</i> )	49.52	Unsatisfactory
4	MP ( <i>Mathematical Procedures</i> )	47.12	Unsatisfactory
5	LP ( <i>Logical Progression</i> )	42.64	Unsatisfactory
Average		49.94	Unsatisfactory

Based on research conducted also showed that the problem-solving ability of women's class learners is greater than the problem-solving ability of the men's class. The women's class got an average percentage of 57.14% with a fairly satisfactory theory, while the men's class got an average percentage of 44.52% with a less satisfactory category. This is because female learners have superior abilities in every aspect of problem-solving indicators used. However, there are also some male learners whose math problem solving skills can be superior to female learners (Sanglimbo Buranda et al., 2018). The answers given by male learners tend to provide alternative answers, but do not explain the problem in detail and detail on each indicator of solving. While the answers of female learners always provide comprehensive and detailed answers on each indicator of problem solving Factors that cause problem-solving abilities of female learners superior to male learners are more serious and caring female learners during classroom learning (Trianggono & Yuanita, 2018). Female learners are more active in asking questions related to the topic. In contrast, male learners used to joking around and ask questions that have nothing to do with the material described during the learning (Hartanti et al., 2021).

**CONCLUSION**

Based on the results of the study it can be concluded that the problem-solving ability profile of X MIPA learners at SMAM X Surabaya is still relatively low with a percentage of 49.94% of unsatisfactory categories. The highest learner problem-solving indicator is UD (Usefull Description) with a percentage of 58.88% and the lowest is LP (Logical Progression) with a percentage of 42.64%. The problem-solving ability of women's class learners is greater than the men's class problem-solving ability. The women's class got an average percentage of 57.14% with a fairly satisfactory theory, while the men's class got an average percentage of 44.52% with a less satisfactory category. These results prove that learners have their own

abilities and advantages. Formative assessments have a positive impact on the problem-solving abilities of parabolic motion material learners. Proper learning models are needed accompanied by more complex formative assessments on other physical materials in the learning process so that learners experience improved problem-solving skills and are accustomed to answering questions based on indicators of problem-solving abilities.

## RECOMMENDATION

Teachers are strongly encouraged to employ formative principles. Teacher can collaborate with learners to obtain direct feedback on how their learning progresses in terms of comprehending the topic or content presented and informing the choice regarding the next steps to be done in the learning process. The outcomes of formative feedback can be utilized to improve learners' learning activities in order to foster common understanding and establish criteria for achieving learning goals.

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