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How Creative Problem-Solving Model Boosts Students' Mastery of Gravity

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Abstract:- This study aims to describe the effectiveness of teaching materials of Newton's law on gravity through creative problem solving models to improve problem-solving skills. The method used is research and development with the ADDIE model. The design of the research trial is pre experiment design (the one group pretest-posttest design). The subjects of the trial in this study were 17 students of class X of the mathematics and natural sciences program at SMAN 1 Amuntai. The data collection technique was obtained through the student's pretest and posttest learning outcomes test instruments consisting of 6 essay questions with a C4 level. Data analysis was carried out with an n-gain test of pretest-posttest learning outcomes to measure effectiveness. The results showed that the average teaching material effectiveness of 5.47 categories of pretest was not good, and the average posttest of 50.23 categories was quite good, as well as an n-gain score of 0.47 moderate categories, so that the teaching material of Newton's law on gravity through the creative problem solving model to improve problem solving skills was declared effectively used in learning.

Keywords:- *Creative Problem Solving, Problem Solving Skills, Teaching Materials.*

I. INTRODUCTION

Physics serves as a fundamental science that helps students understand the natural phenomena around them. Learning physics involves developing various skills, particularly problem-solving abilities. The goal of teaching physics is to enable students to master concepts, employ scientific methods, and apply them with a scientific mindset (Dwi Sambada, 2012). According to Plotzener in Susiana, Yulianti, and Latifah (2017), solving problems efficiently is a valuable approach for studying physics and tackling physics-related questions independently and consistently. Effective problem-solving requires students to first learn the necessary concepts and then apply them to specific situations by following appropriate steps (Thersia et al., 2019). Therefore, encouraging students to practice problem-solving helps them develop essential problem-solving skills.

Problem-solving skills are foundational abilities that involve critical, logical, and systematic thinking (Nayazik, 2017). According to Misbah (2016), enhancing problem-solving skills can be achieved through problem-solving-oriented learning and continuous practice. This approach helps students become accustomed to solving problems by following complete steps, from understanding the problem to finding solutions and verifying the results.

Research conducted by Rahimah, Salam, and Haryandi (2021) at SMA Negeri 10 Banjarmasin indicates that students have low problem-solving skills. Interviews at SMAN 1 Amuntai revealed that students struggle with physics problems at the C3 level and higher, particularly when it comes to analyzing and solving questions. The first step in problem-solving is understanding the problem and analyzing it. This leads to the second step of identifying the known and unknown variables and applying the correct equations. Students often do not recheck their answers or draw conclusions, highlighting their need for improvement in problem-solving skills.

The low problem-solving skills are attributed to the lack of teaching materials that emphasize problem-solving strategies. Therefore, there is a need for teaching materials that integrate problem-solving skills to help students improve in this area.

Improving the quality of physics education can be achieved by developing teaching materials based on a creative problem-solving model. These materials should be clear, detailed, and include numerous examples to make complex concepts easier to understand (Prastowo, 2015). Most importantly, the materials should encourage active student participation, which enhances their problem-solving skills. Research by Habibi, Zainuddin, and Misbah (2017) supports this, indicating that science materials focused on problem-solving skills are effective for learning.

The topic that entails and improves the problem-solving skills of learners is the material of Newton's law of gravity. On this topic, learners are introduced to concepts/principles/laws related to gravity. The matter of Newton's law of gravity has the characteristic of being matter whose object of discussion revolves around extraterrestrial bodies, such as planets, satellites, stars, and the regularity of these celestial bodies. The complicated material makes Newton's law of gravity appropriate for improving problem-solving skills. Furthermore, students are expected to be able to solve problems related to the application or applicability of the concept / principle / law. With such material characteristics, teachers can choose methods / strategies / models that are able to improve basic knowledge and skills first then apply them with problem solving.

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Many studies have explored the development of teaching materials aimed at enhancing problem-solving skills. However, there has not yet been a focus on creating teaching materials that integrate problem-solving skills with the *creative problem-solving* model. According to Pepkin in Indrasari (2021), the *creative problem-solving* model emphasizes both teaching and reinforcing problem-solving abilities. This model encourages students to approach problems creatively and use their problem-solving skills effectively. Rendhana (2008) highlights that fostering problem-solving skills helps develop critical thinking through hands-on learning experiences. Effective problem-solving requires critical thinking as well as timely and accurate decision-making.

The *creative problem-solving* model also enhances students' comprehension of physics concepts. Saprudin (2010) stated that this model engages students in activities designed to solve specific problems. By tackling real-world problems, students gain practical experience, which helps them retain the concepts longer.

Given the challenges related to students' low problem-solving skills, the researcher aims to address this issue by developing teaching materials. The study focuses on Newton's law of gravity, applying the *creative problem-solving* model to improve students' problem-solving abilities. The objective of this research is to evaluate the effectiveness of these materials in enhancing students' problem-solving skills.

II. METHOD

The research conducted falls under the category of research and development (R&D). The ADDIE model, which consists of five phases — Analyze, Design, Development, Implementation, and Evaluation — was employed for this study. The trial used a one-group pretest-posttest design, as illustrated in Figure 1, with the research steps detailed in Table 1.

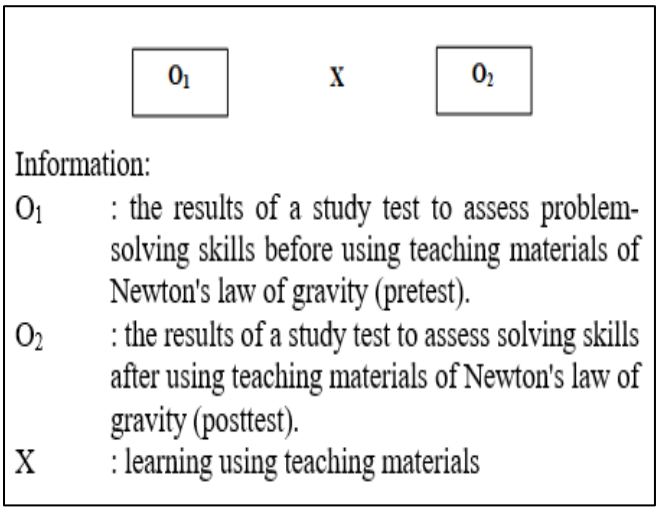

Fig 1: Trial Design

The study took place at SMAN 1 Amuntai in February 2022. The participants were 17 students from class X MIPA 2. The focus of the research was the development of teaching materials on Newton's law of gravity using the creative problem-solving model to enhance students' problem-solving skills.

The instruments used consist of learning outcomes test instruments in the form of pretests and posttests. Data collection techniques are carried out through tests. Data analysis was carried out by n-gain test of pretest-posttest learning outcomes calculated by equation (1) and categorized as in Table 2.

Table 1: Explanation of the Stages of Teaching Material Development with the ADDIE Model

Development Steps	Activity
Analyze	An analysis was conducted on current products and field needs, the curriculum, the specific characteristics of Newton's law of gravity material, and the attributes of the learners.
Design	The teaching materials are developed to incorporate problem-solving skills and are organized using the *creative problem-solving* model.
Development	In this activity, the researchers create teaching materials following a development-based design approach.
Implementation	The developed products are implemented in real-world settings, specifically within teaching and learning activities.
Evaluation	The evaluation phase is categorized into two types: formative and summative.

The effectiveness of teaching materials is defined as improving problem-solving skills using developed teaching materials, in terms of problem-solving skills in students and measured by pretest and posttest cognitive learning outcome tests set with an n-gain score, expressed with the categories of high / very effective, medium / effective, low / less effective. Teaching materials are said to be effective if they have at least a medium / effective category.

Data from the THB pretest posttest is calculated using an average n-gain score where the equation is as follows:

$$\langle g \rangle = \frac{\%\langle G \rangle}{\%\langle G \rangle_{max}} = \frac{\left(\%\langle S_f \rangle - \%\langle S_i \rangle\right)}{\left(100 - \%\langle S_i \rangle\right)} \quad (1)$$

Information:

$\langle g \rangle$: n-gain score average
$\langle S_f \rangle$: average posttest score
$\langle S_i \rangle$: average pretest score

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Table 2: N-Gain Category

No	Interval	Category
	$(\langle g \rangle) \geq 0{,}7$	High/very effective
	$0{,}7 > (\langle g \rangle) \geq 0{,}3$	Medium/effective
	$(\langle g \rangle) < 0{,}3$	Low/less effective

Adapted from Hake (1998)

III. FINDING AND DISSCUSION

The ADDIE model used in this study starts from the analysis stage, one of which is the analysis of existing products and needs in the field. The results of the analysis of existing products and the need in the field for package books identified several shortcomings, including that the book was provided on a limited basis so that not all students could borrow the book in the library, the book used did not include problem-solving skills in it, and there was no answer key in the competency test. Based on these facts, a teaching material is needed that contains problem-solving skills in it. The teaching materials developed also contain a creative problem solving model, which requires students to solve problems creatively.

In the design stage, researchers design problem-solving skills in the design of each example of the problem in the teaching material. The creative problem solving model is designed in the CPS dialogue section, which shows how to solve problems creatively using problem-solving skills by Heller. The next stage is development, researchers develop teaching materials for Newton's law of gravity through creative problem solving models to improve problem-solving skills. The developed product is then validated by the validator. The validation results are then analyzed to find out the validity of the product being developed and further improvements are made in accordance with the advice of the validator if needed.

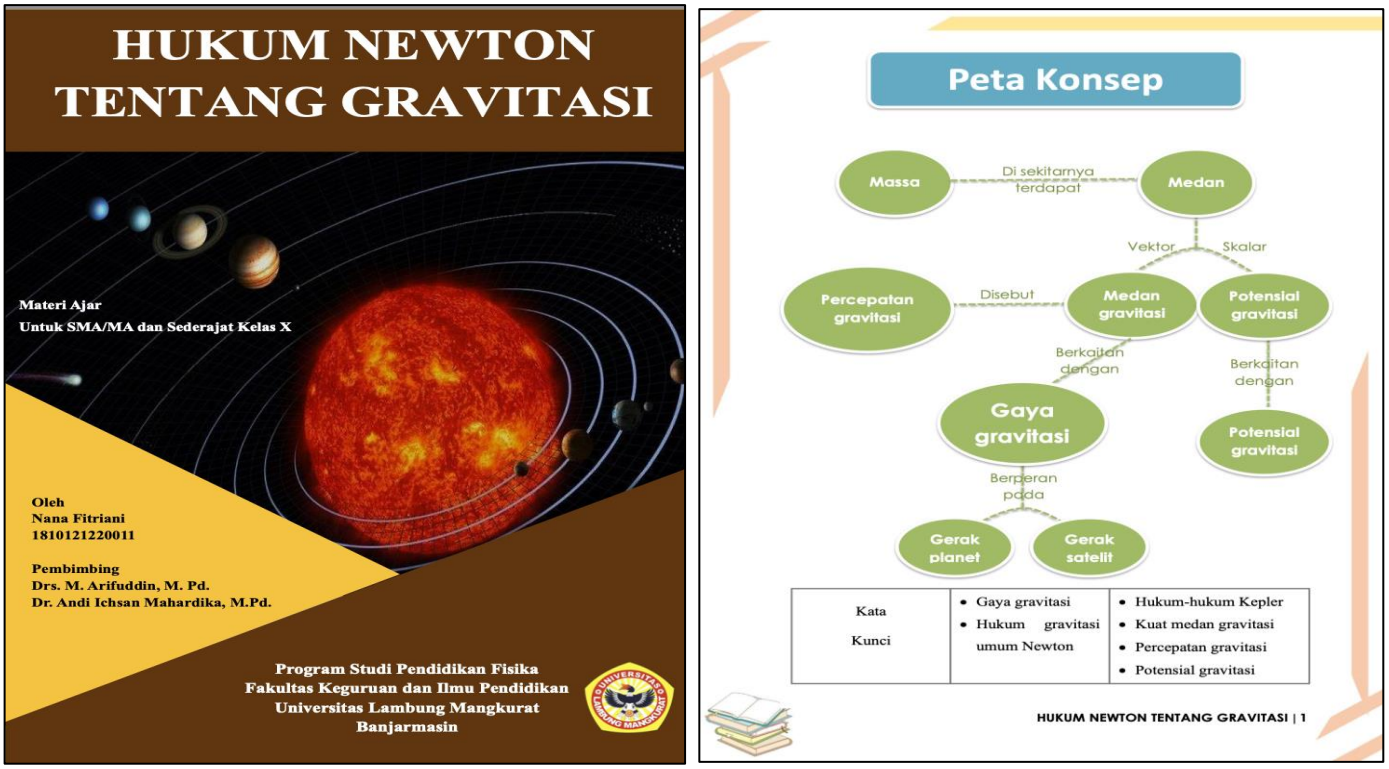

Fig 2: Front Cover of Teaching Materials and Concept Map

The implementation stage of the product that has been developed is applied to the real situation, namely in teaching and learning activities in the classroom. Product trials in the classroom were carried out as many as 3 meetings in 24 students of class X MIPA 2 at SMA Negeri 1 Amuntai. The last stage is evaluation, formative evaluation is carried out at each stage of development, while summative evaluation is carried out at the end of the research implementation test.

The teaching materials developed consist of the front cover, foreword, introduction, table of contents, concept map, learning objectives, material, LKPD, sample questions, CPS dialogues, summaries, competency tests and answer keys, and bibliography. Figure 2 presents the front cover of the teaching material and concept map.

Figure 3 shows an example of problem solving using indicators of problem-solving skills by Heller which consists of describing problems, describing problems in physics concepts, planning solutions, implementing plans, and checking and evaluating. Figure 4 shows the CPS dialogue, containing information on how to solve problems creatively using the creative problem solving model. The CPS dialogue also provides an explanation of the diverse solutions that learners can use to find solutions to problems with heller's stages of problem-solving skills. The CPS dialogue also creates a complete creative problem solving model syntax

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starting from the phase of problem clarification, opinion disclosure, evaluation and selection, and implementation.

The effectiveness of teaching materials to assess problem-solving skills using learning outcomes test instruments, which are supported by research from Awaliyah (2015) which uses test instruments to determine students' problem-solving skills. Pretest is a test that is based on a test procedure in the form of a test before being given learning, and a test after being given learning is called a posttest. The tests given were six questions in the form of essays based on bloom's taxonomy with a KKM of 70. After the test was carried out, data were obtained that were calculated using an average n-gain score using equation (1) to determine the effectiveness of teaching materials. The average N-gain score obtained on the effectiveness of this teaching material is categorized as moderate or effective. The effectiveness of teaching materials is supported by the learning outcomes of students using developed teaching materials (Misbah et al., 2016).

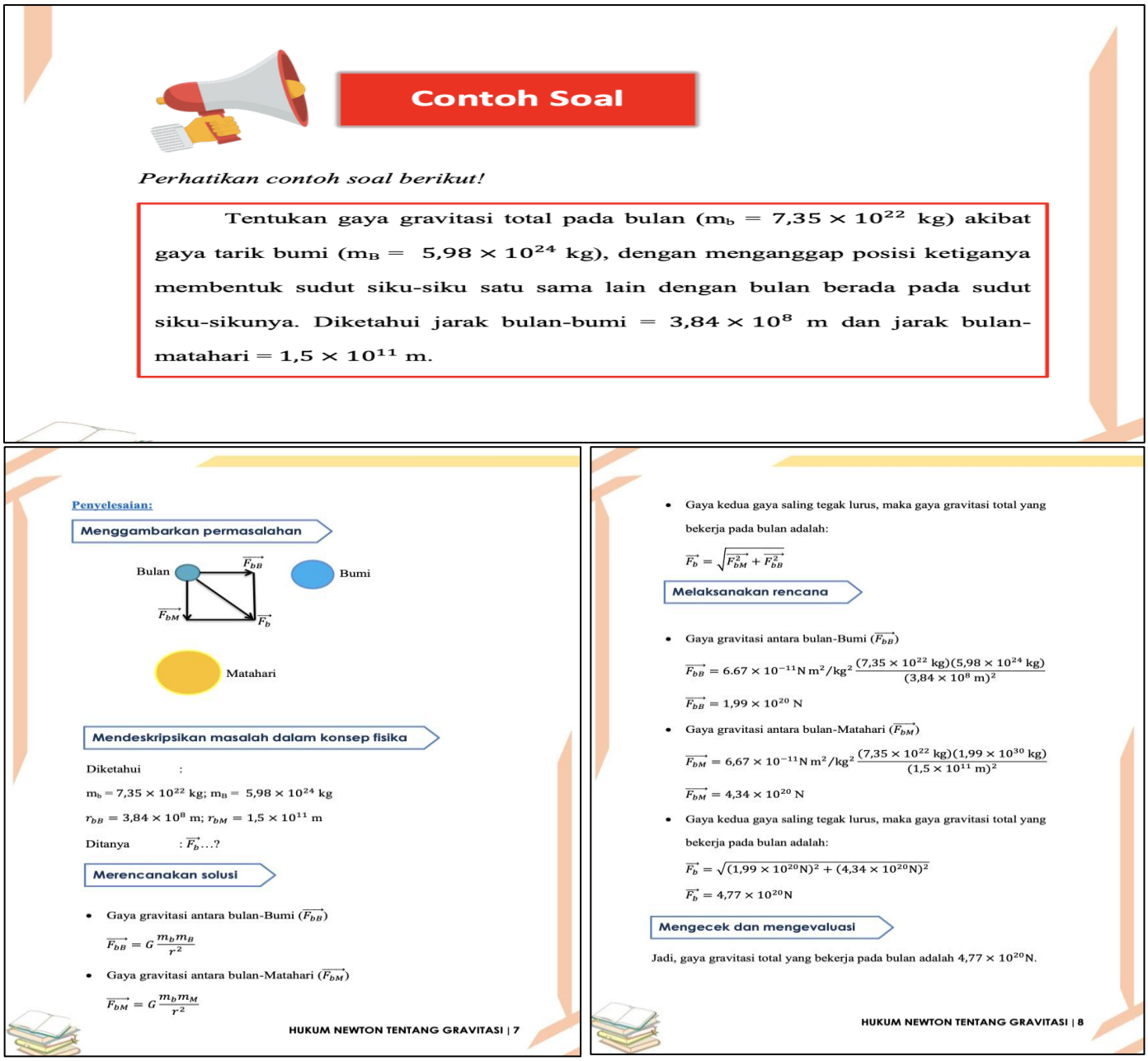

Fig 3: Examples of Problems with Solving Using heller's Problem Solving Skills Indicator

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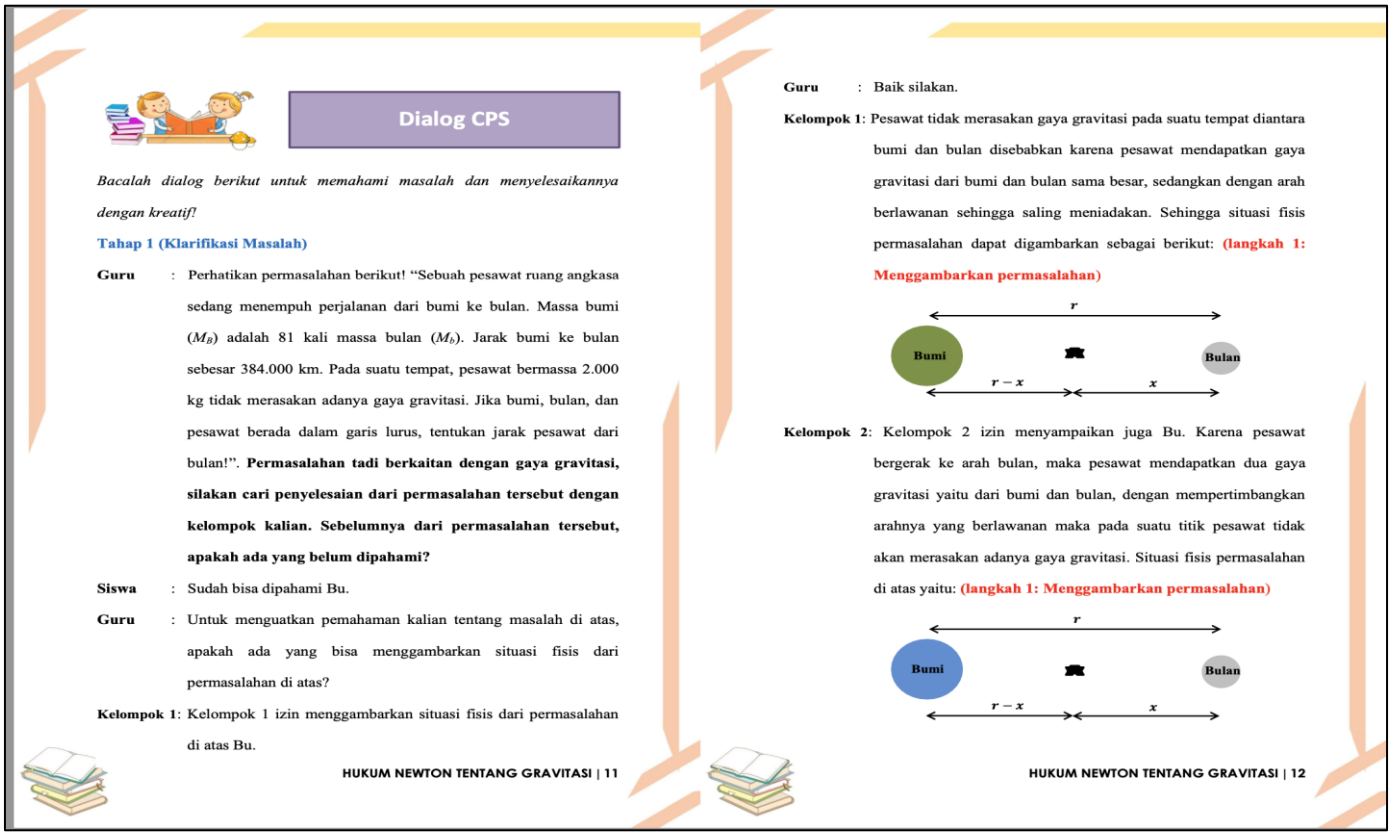

Dialog CPS

Bacalah dialog berikut untuk memahami masalah dan menyelesaikannya dengan kreatif!

Tahap 1 (Klarifikasi Masalah)

Guru : Perhatikan permasalahan berikut! "Sebuah pesawat ruang angkasa sedang menempuh perjalanan dari bumi ke bulan. Massa bumi (M_B) adalah 81 kali massa bulan (M_b). Jarak bumi ke bulan sebesar 384.000 km. Pada suatu tempat, pesawat bermassa 2.000 kg tidak merasakan adanya gaya gravitasi. Jika bumi, bulan, dan pesawat berada dalam garis lurus, tentukan jarak pesawat dari bulan!". **Permasalahan tadi berkaitan dengan gaya gravitasi, silakan cari penyelesaian dari permasalahan tersebut dengan kelompok kalian. Sebelumnya dari permasalahan tersebut, apakah ada yang belum dipahami?**

Siswa : Sudah bisa dipahami Bu.

Guru : Untuk menguatkan pemahaman kalian tentang masalah di atas, apakah ada yang bisa menggambarkan situasi fisis dari permasalahan di atas?

Kelompok 1: Kelompok 1 izin menggambarkan situasi fisis dari permasalahan di atas Bu.

Guru : Baik silakan.

Kelompok 1: Pesawat tidak merasakan gaya gravitasi pada suatu tempat diantara bumi dan bulan disebabkan karena pesawat mendapatkan gaya gravitasi dari bumi dan bulan sama besar, sedangkan dengan arah berlawanan sehingga saling meniadakan. Sehingga situasi fisis permasalahan dapat digambarkan sebagai berikut: **(langkah 1: Menggambarkan permasalahan)**

Kelompok 2: Kelompok 2 izin menyampaikan juga Bu. Karena pesawat bergerak ke arah bulan, maka pesawat mendapatkan dua gaya gravitasi yaitu dari bumi dan bulan, dengan mempertimbangkan arahnya yang berlawanan maka pada suatu titik pesawat tidak akan merasakan adanya gaya gravitasi. Situasi fisis permasalahan di atas yaitu: **(langkah 1: Menggambarkan permasalahan)**

Guru : Baik, bagus sekali karena kalian sudah memahami permasalahan di atas, selanjutnya silakan berdiskusi dengan mengungkapkan pendapat bersama kelompok untuk menyelesaikan masalah tersebut. Gunakan tahapan keterampilan pemecahan masalah untuk menemukan penyelesaian dari permasalahan.

(Siswa aktif dalam mencari solusi jawaban dan mengungkapkan pendapat sebanyak-banyaknya berkaitan dengan strategi atau solusi pemecahan masalah).

Guru : Bagaimana apakah kalian sudah menemukan kemungkinan-kemungkinan strategi pemecahan masalah?

Tahap 2 (Pengungkapan Pendapat)

Kelompok 1 : Izin menyampaikan Bu. Kalau dari kelompok kami, **(Langkah 2: Mendeskripsikan masalah dalam konsep fisika)** diketahui yaitu $M_B = 81\ M_b, r = 384.000$ km, $m = 2000$ kg, ditanyakan yaitu jarak pesawat dari bulan atau (x)? Maka dari hal tersebut akan berlaku: **(Langkah 3: Merencanakan solusi)**

$$\overrightarrow{F_{PB}} = \overrightarrow{F_{pb}}$$

Sehingga:

$$G\frac{M_B m}{(r-x)^2} = G\frac{M_b m}{x^2}$$

Kelompok 2 : Izin menyampaikan juga Bu. **(Langkah 2: Mendeskripsikan masalah dalam konsep fisika)** Diketahui yaitu $M_B = 81 M_b, r =$

384.000 km, $m = 2000$ kg, ditanyakan yaitu jarak pesawat dari bulan atau (x)? Karena F dan m bernilai tetap, maka: **(Langkah 3: Merencanakan solusi)**

$$r \approx \sqrt{M}$$

$$\frac{x}{(r-x)} = \sqrt{\frac{M_b}{M_B}}$$

Tahap 3 (Evaluasi dan Pemilihan)

Guru : Baik, selanjutnya mari kita evaluasi dulu terhadap strategi yang kalian uangkapkan tadi. Untuk kelompok 1 menggunakan persamaan gaya gravitasi yang nantinya dilakukan perbandingan kemudian diakarkan dan dikalikan untuk memperoleh hasil. Sedangkan strategi pemecahan masalah kelompok 2 menggunakan persamaan gaya gravitasi yang nantinya akan langsung dilakukan perbandingan untuk memperoleh hasil. Dengan demikian strategi pemecahan masalah yang diungkapkan kelompok 1 dan 2 dapat digunakan. Selanjutnya silakan kalian memutuskan strategi pemecahan masalah yang akan digunakan untuk menyelesaikan permasalahan.

Siswa : Baik Bu.

Fig 4: CPS Dialogue

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Based on the results of the n-gain of the pretest section, it shows that the learner's score is very low and the learner's ability to solve the questions of Newton's law of gravity is very low. In this pretest, students are able to determine the variables that are known and asked. However, students have not been able to visualize problems so that students have not been able to determine the appropriate formula and have not been able to use the formula to obtain the correct value. Learners also do not make conclusions on the answers obtained.

Based on the results of the n-gain on the posttest, students have been able to describe the problem so that students are able to determine the appropriate formula and are able to use the formula to obtain the correct value. Next, the learner conducts a re-examination and makes his conclusions. This is because the teaching materials used contain problem-solving skills in each example of the problem, which makes students trained to use indicators of problem-solving skills. Students are also able to answer questions creatively, this is because they use a creative problem solving model during learning that frees students to answer questions creatively using the correct physics concepts and principles. According to Hidayat 2016) in learning with a creative problem solving model, students must solve problems creatively. This model provides an opportunity for learners to develop skills to solve problems. In addition, the models used can also be very helpful in improving the mastery of physics concepts. So it can be said that this teaching material can improve students' problem-solving skills.

Based on Table 3, the average N-gain score of the THB pretest posttest is obtained in the moderate category. The acquisition of moderately categoryed N-gains also shows that teaching materials are able to improve the cognitive abilities of students, especially improving students' problem-solving skills.

Table 3: Results of the Effectiveness of Pretest-Posttest Teaching Materials

Average Pretest	**Average Posttest**	***Average N-Gain Score***	**Category**
5,47	49,91	0,47	Medium

The effectiveness of the teaching materials also assesses each indicator of problem-solving skills by Heller that learners use when working on pretest posttests. Indicators of problem-solving skills used to improve students' problem-solving skills are: 1) visualize the problem; 2) describe the physics; 3) plan the solution; 4) execute the plan; 5) check and evaluate. The results of the calculation of pretest posttest problem solving skills are shown by Table 4 as follows.

Table 4: The Result of the Calculation of Pretest Posttest Problem Solving Skills

Problem Solving Skill indicator	***Pretest***		***Posttest***	
	Average	**Category**	**Average**	**Category**
Visualize	0,25	Not good	41,67	Good enough
Identify	26,71	Not good enough	57,93	Good enough
Plan	0,41	Not good	52,54	Good enough
Execute	0	Not good	56,62	Good enough
Evaluate	0	Not good	42,40	Good enough
PSS Achievements	5,47	Not good	50,23	Good enough

The results of obtaining the effectiveness of this medium category are inseparable from the role of teaching materials used by students. The teaching material provides sample questions using heller's indicators of problem-solving skills on a step-by-step basis, which allows learners to practice using these indicators. The teaching material is also equipped with a CPS dialogue, which provides an explanation that students can answer questions creatively, this is because it uses a creative problem solving model during learning that frees students to answer questions creatively using the correct physics concepts and principles. Working on tests using problem solving can make learners trained in using these skills. In accordance with Handayani (2017) explanation that learning by solving problems can make learners become more skilled in making decisions in their lives.

This increase in learning outcomes also explains that students' problem-solving skills increase after using teaching materials that contain problem-solving skills in them.Anisah, Wati, & Mahardika (2016) in their research revealed that teaching materials can be said to be effective if they produce results in accordance with learning objectives. This is supported by Awaliyah research (2015) which states that problem-solving skills have a good impact on student learning outcomes, meaning that the quality of student learning outcomes increases along with the increase in these skills.

IV. CONCLUSION

Based on the results of the research, teaching materials have been obtained for Newton's law on gravity through a creative problem solving model to improve problem-solving skills. This is based on the effectiveness of teaching materials to assess problem-solving skills through the pretest-posttest learning outcomes test obtaining the moderate category. Thus, it was concluded that the teaching material of Newton's law on gravity through a creative problem solving model to improve problem-solving skills was effectively used in the learning process.

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