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Development of Science Learning Devices Using the Team-Based Learning (TBL) Model with the Assistance of Phet Simulation on The Vibration Concept to Improve Learning Outcomes for Students

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Abstract: Strengthening the 2013 curriculum learning process is carried out through an approach known as a scientific approach that starts with observing, asking, trying, associating and communicating. Through learning activities using a scientific method, one of which is with the help of the Phet simulation, which is expected that students will be able to achieve graduate competency standards. In Team-Based Learning (TBL) learning, the activities carried out by students are mostly used for group activities, such as completing worksheets or tests given by the teacher. One of the assignments or tests is an experiment using a Phet simulation. The results of the activities carried out by the teacher can be used to create more structured groups. The device development model in this study uses the 4-D (four-D) model, which consists of (1) Define, (2) Design, (3) Development, and (4) Disseminate. Based on the results of the research and development of Team-Based Learning devices that have been carried out at SMP Negeri 2 Pulubala, several conclusions can be drawn: Through this research, science learning devices were produced that were valid, practical, and effective. The developed learning device is assessed by a construct validity test with a valid category with minor revisions/slight revisions to fulfil the eligibility validity as a learning device. Likewise, in terms of practicality, team-based learning-problem solving learning devices have met the level of suitability in terms of the implementation of learning and teacher and student response questionnaires. There was a significant change in the average score of students from pretest to posttest in individual and group tests after implementing Team-Based Learning devices. Using Phet simulations as learning media can facilitate the learning process in science learning.

Keywords: Learning Outcomes; Phet Simulation; Science; Team-Based Learning.

Introduction

Education is a demand for every citizen, both young and old. Implementing education is expected to equip every human resource with knowledge, skills and skills to become functional. Furthermore, this education will motivate human resources who want to develop themselves and participate actively, innovatively and productively in development according to the needs and expectations of society (Majid et al., 2020).

The process of organizing education in schools aims to improve students' quality, which means helping improve students' ability to solve problems encountered in schools. So that the school as a place where learning takes place needs to facilitate students to be successful in education, in the sense that the learning process carried out at school can provide sufficient knowledge for students to see, analyze and solve real-life phenomena faced by students every day (Parerva et al., 2020; Hermanto et al., 2023; Buhungo et al., 2023).

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Learning the 2013 curriculum with its characteristics emphasizes an integrated learning process with a scientific approach and authentic assessment directed at developing the three domains of knowledge, attitudes and skills. The teacher's ability to properly plan, implement and evaluate learning is essential in realizing the expected learning objectives (Kurniati, 2013; Sudiarman et al., 2015; Payu et al., 2023).

Strengthening the 2013 curriculum learning process is carried out through an approach known as a scientific approach that starts with observing, asking, trying, associating and communicating. Through learning activities using a scientific method, one of which is with the help of the Phet simulation, which is expected that students will be able to achieve graduate competency standards (Saputra et al., 2020; Setiani et al., 2015; Abdjul et al., 2022).

Curriculum development is significant, and curriculum is one element that contributes significantly to realizing the process of developing the potential quality of students. So, it cannot be denied that a competency-based curriculum is needed as an instrument to direct students to: (1) qualified human beings who are capable and proactive in responding to the challenges of the ever-changing times; and (2) educated people who believe in and fear God Almighty, have a noble character, are healthy, knowledgeable, capable, creative, independent; and (3) democratic and responsible citizens (Haagen et al., 2020).

Science teachers play an essential role in efforts to improve the quality of science learning. To organize science learning that is active, creative, and effective and achieve its learning goals, teachers need to design science learning devices well, use appropriate approaches, varied learning models and methods, exciting media, and use good evaluation instruments (Listyawati, 2012; Rosba, 2015; Ntobuo et al., 2023). A good learning process also depends on good planning, implementation and evaluation. For this reason, teachers must be able to develop appropriate learning devices following developing the applicable curriculum, regional potential and student characteristics (Nugraheni, 2020).

But in reality, science learning outcomes are still low in the field, and assessments are generally still limited to the knowledge aspect. The learning device used is still using a textual approach. In general, students tend to be passive because the learning pattern is still teacher-centred, using the lecture method to make students less motivated, less developed scientific thinking skills, and less creative and innovative, reflected in their learning outcomes (Sahidu et al., 2018; Kharida et al., 2009; Amali et al., 2023; Setiawan et al., 2023).

Besides that, based on the results of supervision of learning in class, teachers generally make learning devices by copy-paste (only adoption). Not all teachers can adapt them or adapt them to school conditions or regional characteristics. Many teachers still need to develop learning devices based on theories or models of experts due to ignorance of the views or models for developing these learning devices (Rotgans et al., 2019). From this situation, the teacher must carry out a good learning process or condition to achieve the learning objectives. To improve the quality of learning science in particular, a change in strategy is needed in developing learning devices, implementing teaching and learning activities and the assessment system. One learning model that is expected to be able to solve these problems is the Team Based-Learning learning model (Akbar, 2013; Asriyadi, 2018; Yuniarti et al., 2014; Hamid, 2016).

Team-Based Learning (TBL) or team-based learning is an active group-based learning strategy that works together to learn and apply lesson concepts. Activities in this model are individual work, teamwork, and quick feedback, which is carried out in a structured format of pre-class preparation, individual and group readiness tests, and application exercises (Dwirahayu, 2018; Fahrurrozi et al., 2020).

Team-Based Learning (TBL) is an innovative learning model that was first developed by Michaelsen et al. (2008). This learning model is an educational strategy based on student-centred and structured teaching and learning activities to enhance learning. TBL is designed to provide conceptual and procedural knowledge to students properly. In Team-Based Learning learning, activities carried out by students are mainly used for group activities, such as completing worksheets or tests given by the teacher. One of the assignments or tests is an experiment using a Phet simulation. The results of the activities carried out by the teacher can be used to create more structured groups (Diniaty et al., 2015; Dwirahayu, 2018; Michaelsen et al., 2014; Situmorang, 2017).

Based on the background described above, the researcher is interested in conducting research by raising the research title "Development of Science Learning Devices Using the Team Based-Learning (TBL) Learning Model Assisted by Phet Simulation on the Vibration Concept to Improve Student Learning Outcomes at SMP N 2 Pulubala". The benefit of this research is to improve the learning process, which is structured, conceptual, and procedural knowledge to students properly.

Method

In this research, the researcher chose State Middle School. 2 Pulubala, Gorontalo Regency, for the

2021/2022 academic year, where the researcher is carrying out his duties as an educator. The subject of research is class VIII students. This research was conducted in an even semester, namely from January to February 2022, with the implementation of the learning process based on the 2013 curriculum.

This research is research and development (Research and Development), namely research and development (research & development) of integrated science learning devices for junior high schools with the concept of vibration with a scientific approach using the 4-D model. The learning devices developed include; Syllabus, Learning Implementation Plan, Student Worksheets, teaching materials, Learning Media, and Learning Outcomes Tests.

Following the 4-D development model (Four-D Models), the research procedure includes four stages, namely: (1) Define stage includes front-end analysis, learner analysis, analysis material (concept analysis), task analysis (task analysis), and analysis of specific learning objectives; (2) The design stage aims to design learning devices. The activities carried out at this stage are the preparation of learning outcomes tests, media selection, format selection, and initial design; (3) The development stage aims to produce learning devices that have been validated. The development stage includes validation of learning devices by experts followed by revisions, limited trials in classroom learning and revisions of learning devices based on the results of trials; (4) The dissemination stage aims to test the effectiveness of the use of learning devices that are suitable for use in learning activities carried out through the implementation of device socialization to similar science teachers or other subject teachers in the same school or involving teachers in other schools, through Newton Science Subject Teacher Deliberation Forum (MGMP) Gorontalo District. It is even possible to enter through research journals at related institutions. The flow of the stages of the 4-D development model in this study can be seen in Figure 1.

Figure 1. Device development flowchart 4D learning

The instruments used in data collection in this study include aspects of validity, practicality and effectiveness. The devices used are (1) learning device validation sheets; (2) observation sheets of learning activities; (3) and learning achievement tests to determine students' initial abilities and as an evaluation device after the implementation of learning activities; (4) Learning adherence sheet; (5) Questionnaire of students' responses to the use of teaching-learning devices with the Team-Based Learning (TBL) learning model assisted by Phet at SMP 2 Pulubala.

All components assessed on this validation sheet are based on Permendikbud number 65 of 2013 concerning primary and secondary education process standards. This sheet includes: 1) Learning Syllabus, 2) Learning Implementation Plan, 3) Student Worksheets, 4) Teaching Materials, 5) Learning Media, and 6) Learning Outcomes Test.

Data analysis in this study was used to determine the quality of science learning devices on the concept of vibration that was developed. The data obtained from this study are qualitative data and quantitative data.

Result and Discussion

Development of Science Learning Devices with the Phet Simulation Assisted Team-Based Learning (TBL) Learning Model on the Vibration Concept at SMP 2 Pulubala, which was developed includes Syllabus, Learning Implementation Plans, Student Worksheets, Teaching materials, Knowledge Competency assessment instruments, Attitudes and Skills. The developed learning device can be high quality if it fulfils three aspects: validity, practicality and effectiveness.

Learning Device Validation Results

The validator's assessment of learning devices is based on format, content and language assessments contained in the syllabus validation sheet instruments, lesson plans, teaching materials, worksheets, tests and observations of science process skills conducted through Forum Group Discussions (FGD). Based on the validation sheet analysis results, the learning device is included in the valid category with minor revisions so that the device can be tested. This is shown in Table 1.

Results of the Practicality of Learning Devices

The practicality of a learning device can be seen through the implementation of learning carried out by the teacher and student responses using learning devices with the Phet-assisted Team-Based Learning (TBL) learning model at SMP 2 Pulubala.

Based on the results of the analysis of the average implementation of learning in limited trials conducted

on 13 students for three meetings shown in Table 2, the average percentage was obtained at 81.12% with good criteria so that learning devices developed using the Team-Based learning model Problem Learning (TBL) is said to be practical and can be widely tested. In the widespread trial, the implementation of learning using Phet-assisted TBL learning devices was very good. The average performance of teacher activities is 91.1%, with excellent criteria, as shown in Table 3.

While the responses of students and teachers to the use of learning devices with the Phet-assisted Team-Based Learning (TBL) learning model at SMP 2 Pulubala, both in limited trials and widespread trials found that the majority of students stated that the learning process used Team-Based Problem learning devices Practical learning to be applied in class which can be seen in table 4.

Results of the Effectiveness of Learning Devices

The effectiveness of a learning device can be reviewed through Student Activities and Student Learning Outcomes. In student activities, there are ten assessment indicators for each indicator based on three assessment descriptions. Based on the observations, it was obtained that the percentage of the average score of the percentage of student activity during the three meetings was 81.12%, with good criteria shown in Table 5.

Referring to the results of this analysis, learning devices developed using the Phet Simulation-assisted Team-Based Problem Learning models are effective and can be used because they can enhance students' teaching and learning activities. And ready to be tested extensively. In the widespread trial, the analysis of student activities carried out using Phet-assisted TBL learning devices was very good. The average implementation of student activities is 90%, with excellent criteria, as seen in Table 6.

The criteria for the effectiveness of learning devices are also seen from students' learning outcomes both from the cognitive, affective and psychomotor domains carried out by students during the learning process. Based on the results of the analysis performed, it was obtained that the average pretest and posttest individual learning outcomes (iRat) with an average N Gain score of 0.65, while the results of the group pretest and posttest (tRat) with an average N-Gain of 0.69. There has been an increase in learning outcomes tests from the pretest to the posttest of both iRat and tRat. Thus, from the analysis results, the learning devices are effective, as shown in Table 7 (Hake, 1999; Sugiyono, 2015).

Learning outcomes in the affective domain through analysing attitude assessment sheets and self-assessment and peer assessment sheets. Obtained an average percentage of 79.97% in the "Good" category, which includes analysis of the results of the self-assessment received an average percentage of 74.56%. Then the peer assessment analysis results obtained an average percentage of 75.27% in the "Good" category. While the analysis of the average percentage of skills assessment is 79.82% in the good category. This can be seen in Table 8 and Table 9.

Table 1. Data Validation Results of Natural Science Learning Devices Using the Team-Based Learning (TBL) Model Assisted by Phet Simulation on the Vibration Concept

Validation component	Enter Validators	Information
Syllabus	Basic competence can be adjusted according to the availability of experiments on the Phet Simulation	Valid with minor revisions
Lesson plan	- The implementation plan for meeting three learning is adjusted to the research title. - Learning indicators are adjusted again according to operational verbs.	Valid with revisions
Student worksheets	- Learning indicators are adjusted again according to operational verbs.	Valid with minor revisions
Teaching materials	- Adjust the font size. - Added summary - Add image captions	Valid with minor revisions
Assessment Instrument	- Adding tRAT and iRAT questions to the Meeting 2 lesson plan	Valid

Table 2. Data on the Percentage of Limited Trial Learning Implementation

Meetings	Percentage of Learning Implementation (%)	Criteria
1	78.15	Good
2	78.33	Good
3	86.18	Good
Average	81.12	Good

Table 3. Data on the Percentage of Extensive Trial Learning Implementation

Stages	Teacher Activities	Meetings			Achievements (%)
		I	II	III	
Introduction preparation	1. The teacher starts the lesson by greeting and guiding students to pray	5	5	5	100
	2. The teacher gives apperception	4	4	4	80
	3. The teacher conveys essential competencies, learning objectives that students will achieve, and the activities that will be carried out during the learning process.	5	5	5	100
Core activities Readiness Assurance Reading Assignments	4. The teacher gives the task of reading teaching materials for 5 minutes and prepares students to do the iRAT and tRAT pretests.	4	5	4.5	90
Individual test	5. The teacher distributes iRAT pretest questions and invites students to work on iRAT pretest questions	4	5	4.5	90
Group test	6. After the iRAT test, the teacher organizes students into study groups of 5-6 people per group.	5	4	4.5	90
	7. The teacher distributes tRAT test questions, and students work on them.	4	4	4	80
Written appeals	8. The teacher provides opportunities for students to read teaching materials/textbooks to answer unfinished questions	5	5	5	100
Feedback Instructor	9. The teacher allows students to ask questions related to the pretest.	4	4	4	80
	10. The teacher discusses the existing problems and explains the concept so students understand it.	5	5	5	100
Application of Course Concept	11. The teacher distributes student worksheets and conveys to students that student worksheet activities are carried out in groups by discussing	4	5	4.5	90
	12. The teacher guides the study group if they have difficulty working on student worksheets	4	5	4.5	90
	13. The teacher collects the results of students' worksheets	5	5	5	100
	14. The teacher, together with the students, discusses the problems that exist in the student worksheets.	3	5	4	80
Closing	15. The teacher provides an opportunity for students to conclude learning.	4	4	4	80
	16. The teacher distributes teaching materials and conveys matters related to the next meeting.	5	5	5	100
	17. The teacher ends the lesson by praying and greeting	5	5	5	100
	The average achievement of teacher activities (%)				91.1
				Criteria	Very Good

Table 4. Data on the Percentage of Student and Teacher Responses in Limited Trials and Wide Trials

Indicators	Percentage of Learning Implementation (%)	Information
1	84.6	Make students concentrate, comfortable, and effective in learning
2	87.18	Make students enthusiastic, active, and serious about learning the material.
3	84.62	Team-based learning is fun and can relieve boredom during learning.
4	84.62	Team-based learning makes students interested and able to enjoy and feel suitable for applying Vibrations and Waves material.
5	98.08	Team-based learning, students can share knowledge, participate with each other, and listen to opinions between team members.
6	100	Team-based learning can make it easier for students to understand the material and be able to answer questions, and improve learning outcomes
7	100	The use of team-based learning student worksheets in team-based learning can foster curiosity and make it easier to understand the material

Table 5. Data on the Percentage of Student Learning Activities in Limited Trials

Meetings	Percentage of Learning Success (%)	Criteria
1	78.15	Good
2	78.33	Good
3	86.18	Good
Average	81.12	Good

Table 6. Data on the Percentage of Student Learning Activities in the Widespread Trial

Stages	Student Activities	Meetings			Achievements (%)
		I	II	III	
Introduction preparation	1. Students return greetings and read prayers	5	5	5	100
	2. Students listen and apperception conveyed by the teacher	2	4.25	3.125	62.5
	3. Students listen to the teacher's presentation and ask if there are things that are not clear	3.5	3.5	3.5	70
Core activities Readiness Assurance Reading Assignments	4. Students prepare themselves by reading teaching materials and other learning resources	5	5	5	100
Individual test	5. Students work on the pretest questions individually and submit their answers to the teacher when they are finished	3.5	5	4.25	85
Group test	6. Learners join and organize themselves into groups determined by the teacher	5	5	5	100
	7. Students work on the pretest questions in groups	5	4	4.5	90
Written appeals	8. Students re-read teaching materials/textbooks and collect their answers for the teacher when they have finished	3	5	4	80
Feedback Instructor	9. Students ask questions	3.7	5	4.3	87.5
	10. Students listen to the teacher's explanation	5	5	5	100
Application of Course Concept	11. In groups, students work on student worksheet	4	4	4	80
	12. Students ask the teacher if there are things that are not understood	3.5	4	3.75	75
	13. Students collect student worksheet answers	5	5	5	100
	14. Together with the teacher, students discuss the problems that exist in student worksheets	4	4	4	80
Closing	15. Learners conclude learning	3.5	5	4.1	82.5
	16. Students receive teaching materials and listen to the teacher's delivery	5	5	5	100
	17. Students pray with the teacher and answer greetings	5	5	5	100
Average achievement of student activities (%)					90

Table 7. N-Gain scores of iRAT and tRAT learning outcomes

Learning outcomes	Meetings	Pretest	Posttest	Difference	N-gain	Criteria
iRAT	1	35.89	70.61	34.72	0.57	Medium
	2	26.25	67.93	41.68	0.68	Medium
	3	32.53	76.39	43.86	0.65	Medium
tRAT	1	53.23	82.09	28.86	0.61	Medium
	2	57.06	84.75	27.69	0.64	Medium
	3	64.37	89.08	24.71	0.69	Medium

Table 8. Student Affective Learning Outcomes

Meetings	Attitude observation (%)	Self-assessment (%)	Peer assessment (%)
1	78.02	79.24	79.05
2	78.97	71.82	73.08
3	82.94	72.94	73.67
Average	79.97	74.67	73.27

Table 9. Student Psychomotor Learning Outcomes

Meetings	Percentage of skills learning outcomes (%)	Criteria
1	76.50	Good
2	79.63	Good
3	83.33	Good
Average	79.82	Good

Discussion

Learning Device Validity

Expert assessment of learning devices is based on format, content, and language in the syllabus validation sheet instruments, lesson plans, teaching materials, Student Worksheets, tests and observations of science process skills conducted through Forum Group Discussions (FGD). The validation of learning devices is carried out through FGD. The results of the validation state that the learning devices developed are valid and can be used with minor revisions. Based on the validation sheet analysis results, the learning device is included in the valid category with minor revisions so that the device can be tested. This aligns by Riwahyudin (2015) which states that the devices developed are valid and usable.

The practicality of Learning Devices

Assessment of the Practicality of Natural Science Learning Devices Using the Phet Simulation Assisted Team-Based Learning (TBL) Learning Model on the Vibration Concept at Pulubala 2 Middle School in terms of observing the implementation of learning, as well as students' responses to Learning Devices Using the Assisted Team-Based Learning (TBL) Learning Model Phet Simulation on Vibration Concept. As explained by Sudiarman et al. (2015) revealed that development products, in this case, teaching materials, can have practical value if experts state that these teaching materials can be used in learning. Their practicality also refers to implementing learning as planned in the previous learning implementation plan. Sahidu et al. (2018) also explains that a developed product can have practical value if its application in easy learning facilitates its users.

The research found that the average percentage was 81.12% with good criteria, so the learning devices developed using the Team-Based Problem Learning (TBL) learning model was practical and could be widely tested. In the widespread trial, the implementation of learning using Phet-assisted TBL learning devices was very good. The average performance of teacher activities is 91.1%, with excellent criteria.

Student response questionnaires to the development of learning devices are given after learning is complete. The student response questionnaire consists of 7 indicators, including student opinions about team-based learning, student impressions of team-based learning, student attention during group discussions, student learning outcomes after participating in team-based learning, and the effectiveness of using Student Worksheets. The results of the analysis of student responses to learning devices are described in Figure 2.

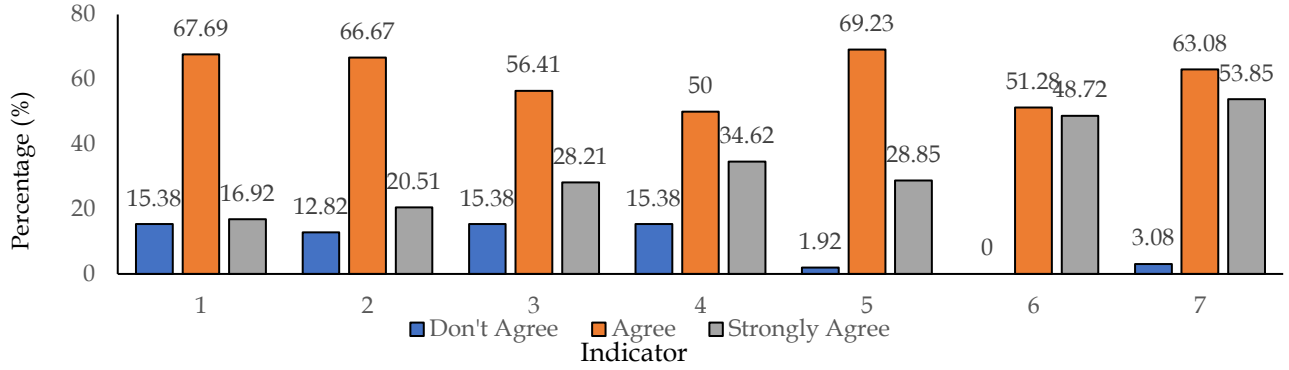

Figure 2. Results of Student Response Analysis

Based on Figure 2. above, in the first indicator, most students (84.62%) stated that team-based learning could make students concentrate, be comfortable, and be effective in learning. In the second indicator, most students (87.18%) said that team-based learning could make students enthusiastic, active and earnest in learning the material of rotational balance and dynamics. In the third indicator, most students (84.62%) stated that team-based learning is fun and can eliminate boredom during learning. In the fourth indicator, most students (84.62%) said that team-based learning made students interested and able to enjoy and feel suitable for applying Vibrations and Waves material. In the fifth indicator, most students (98.08%) stated that in team-based learning, students could share knowledge, participate with each other, and listen to team members' opinions. In the sixth indicator, the majority of students (100%) stated that participating in team-based learning made it easier for students to understand the material and answer questions and improve learning outcomes. In the seventh indicator, most students (100%) stated that using TBL-based worksheets in team-based learning can foster curiosity and make it easier to understand the material.

Based on the results of the questionnaire analysis of student responses as a whole both in the extended test and the limited test, it can be concluded that most students stated that the learning process using the Team-Based Problem Learning device was practical to apply in class.

Results of the Effectiveness of Learning Devices

The Effectiveness of Learning Devices The effectiveness of a learning device can be reviewed through Student Activities and Student Learning Outcomes. In student activities, there are ten assessment indicators for each indicator based on three assessment descriptions. Based on the observations, it was obtained that the percentage of the average score of the percentage of student activity during the three meetings was 81.12% with good criteria.

Referring to the results of this analysis, learning devices developed using the Phet Simulation-assisted Team-Based Problem Learning models are effective and can be used because they can enhance students' teaching and learning activities. And ready to be tested extensively. In the widespread trial, the analysis of student activities carried out using Phet-assisted TBL learning devices was very good. The average implementation of student activities is 90%, with excellent criteria. This aligns with the research results by Dariani et al. (2021) that Team-Based Problem Learning can increase student involvement in learning activities.

The criteria for the effectiveness of learning devices are also seen from students' learning outcomes both from the cognitive, affective and psychomotor domains carried out by students during the learning process. Based on the results of the analysis carried out, it was obtained that the average pre-test and post-test learning outcomes for individuals (iRat) with an average N Gain score of 0.65, while the results of the group pre-test and post-test (tRat) with an average N Gain of 0.69. There has been an increase in learning outcomes tests from pre-test to post-test, both iRat and tRat. Thus, from the analysis results, the learning device is effective. Teachers provide more opportunities to develop collaboration, giving great weight to the discussion process and individual learning abilities. Learning outcomes in the affective domain through analysing attitude assessment sheets and self-assessment and peer assessment sheets. They obtained an average percentage of 79.97% in the "good" category. Analysis of the Self-Assessment results got an average percentage of 74.56%, then the results of the peer assessment analysis received an average percentage of 75.27% in the "Good" category. Judging from these results, it can be concluded that the learning devices developed are effective in terms of the results of the attitude assessment. This is in line with the results research by Riwahyudin, (2015) that student attitudes have a direct positive effect on learning outcomes, meaning that positive student attitudes in learning will lead to good learning outcomes.

Analysis of the average percentage of skills assessment is 79.82% in the good category. This aligns with the research results by Wardani et al. (2019). Improving science process skills can enhance learning outcomes and student learning activities. Based on the analysis results, the devices developed effectively assess knowledge, attitudes and skills. This is in line with the research of Ma'rifatul, (2021). The development of learning devices is likely effective from the average student activity, there is an increase in formative tests, and teachers and students positively respond to using learning devices in class.

Conclusion

This research produces science learning devices that are valid, practical, and effective. The developed learning device is assessed by a construct validity test with a valid category with minor revisions/slight revisions to fulfil the eligibility validity as a learning device. Likewise, in terms of practicality, team-based learning-problem solving learning devices have met the level of suitability in terms of the implementation of learning and teacher and student response questionnaires. There is a significant change in the average score of students from pretest to posttest both on individual tests and group tests after implementing

learning devices of Team-Based Learning. Using Phet simulations as learning media can facilitate the learning process in science learning.

Author Contributions
Juliatin P. Hali: Conceptualization, methodology, writing—original draft preparation, Writing—review and editing; Tirtawaty Abdjul: validation, data curation, Writing—review and editing; Ritin Uloli: Methodology, Formal analysis.

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Conflicts of Interest
The authors declare no conflict of interest.

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