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Article

Developing synergy learning model for science learning: A case study at islamic junior high school

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Abstract: This research aims to develop a Synergy Learning Model in the context of science learning. This research was conducted at Islamic Junior High School, Madrasah Tsanawiyah Negeri 2 Medan, involving 64 students of Grade 7 as the research subject. The method used in this research refers to the development research approach (R&D). In collecting the data, the research employed test and non-test techniques. The results prove that the Synergy learning model developed is effective in improving student learning outcomes. This is evident through the *t*-test statistical test where the *t*-count of 4.26 is higher than the *t*-table of 1.99. In addition, the level of practicality with a score of 3.39 is categorized as practical. This learning model emphasizes the learning process that supports the development of science skills and develops students' competencies in planning, collaborating, and critically reflecting. The findings of this study contribute to pedagogical practices and literature in the field of science learning.

Keywords: development research; synergy learning model; science learning

1. Introduction

Nowadays, the world of education is confronted with new challenges and opportunities in the learning process, especially in science learning. One of the critical challenges is preparing students to be skilled in facing the demands of the 21st century, which emphasizes the ability to think critically to solve problems, be able to communicate and work together in groups to solve problems and be creative in producing innovative solutions (Arends et al., 2001; Reigeluth, 2009; Septikasari and Rafandi, 2018). These competencies are difficult to achieve if the paradigm applied is still nuanced concept transmission, linear problem solving, demands for uniform learning behavior patterns, and teacher-centered learning patterns. If this condition continues, the learning objectives stated in the curriculum and the competencies expected from students will not be achieved. In this regard, each student is expected to be sensitive and flexible to the opportunities around them to survive during global competition.

Besides, in current school conditions, especially madrasah, science learning does not refer to preparing students for the basic knowledge needed. Most science teachers only provide information in textbooks, whereas textbooks are abstract information. This situation is further worsened by the application of learning methods that do not involve the participation of students, who are treated less as learning subjects and more as learning objects. In addition, there is no effort to bring science learning material closer to everyday life problems that interest learners in learning. Nevertheless, the teachers also need to maximally develop the ability to think critically and systematically to understand concepts and principles to solve problems, resulting in students being unable to apply science concepts in everyday life.

In relation to various international reports such as PISA (Program for International Student Assessment) and TIMSS (Trends in International Mathematics and Science Study), it shows that in science learning, the science literacy skills of students in Indonesia are still lower than the international average. It is evident from the data on the achievement of science literacy of Indonesian students for the last three years following the PISA science literacy assessment in 2015, 2018, and 2022, the average achievement of students' science literacy scores is still in the score range of 383–403 (OECD, 2023). Besides the low science literacy ability, the ability to think critically, create, collaborate, and communicate, as well as problem solving of students in Indonesia is also still low (Fitriyani et al., 2019; Nurafiah et al., 2019). The reason for the non-optimal competence of these students is because teachers tend to use conventional learning models because they are considered quite effective in implementing learning activities (Respatiningrum and Akhyar, 2017).

These problems need special attention in developing the potential of human resources through the implementation of independent curriculum-based learning in Indonesia. The skills of the 21st century require teachers to improve their professionalism to improve the quality of learning according to current educational developments (Sulaiman and Ismail, 2020). Therefore, collaborative-based synergy model learning can be used as an alternative in creating meaningful science learning at the secondary school level. By applying the synergy model, it is hoped that it will help teachers increase the quality of learning.

In response to the current quality of education, the government, in this case the Ministry of National Education, issued a policy to implement an independent curriculum (kurikulum merdeka) as an adaptation of the previous curriculum, the 2013 curriculum. Starting from the thought that the achievements of Indonesian students are still weak in international competitions such as PISA and TIMSS, and to improve the quality of education. The core of the independent curriculum is implementing the scientific approach for all subjects. The scientific approach consists of five main components, namely (1) observing natural events/phenomena and subject matter, (2) questioning, drawing attention related to natural phenomena and subject matter, (3) exploring scientific activities to prove conjectures or hypotheses, (4) associating, discovering new things derived from learning experiences, and (5) communicating, presenting by writing reports and presenting the results of group activities in front of the class. Three main domains are highlighted in this curriculum: attitudes, skills, and knowledge.

The collaborative learning model is suitable to be applied to the current learning context and needs to be owned by students because it can support learning achievement (Naude et al., 2014; Ronfeldt et al., 2015). Considering that the current learning paradigm is student centered learning, students are expected to be active and critical individuals in the classroom (Robbins and Hoggan, 2019). The development of a collaborative model is supported by several things. First, the implementation of the Merdeka Curriculum, the independent curriculum states that the purpose of giving science lessons is that students are able to observe, question and predict, plan and conduct investigations, process, analyze data and information, evaluate and reflect and communicate the results of scientific investigations. Second, several learning theories and educational philosophies are relevant to the collaborative model. Among them is Piaget's theory which states that intellectual development is a process carried out actively constructing understanding from the results of experience and interaction with the environment. Learners actively build knowledge by continuously accommodating and assimilating the new information they receive.

In science learning, it is very important for learners to gain true experience. For cognitive constructivists, true experience is essential, because a person can construct an accurate representation of his world, while for radical and social constructivists, true experience is very important. Science provides opportunities to produce creativity, innovation, and technological development (Santyasa et al., 2021). The learning of science allows students to develop understanding, habits of mind, problem solving, and decision making in everyday life (Sengul, 2019). This is crucial for creating a science literate generation. Creating a science-literate society is at the core of scientific learning (Ahied et al., 2020)

Synergy learning is often referred to as collaborative learning and it is constantly emphasized in higher education. The Synergy (collaboration) learning model combines four active learning models: problem-based learning, inquiry learning, discovery learning and project-based learning. This collaborative model of study involves planning, implementing and evaluating programs with students with specific expertise to achieve common goals through high interdependence. (Burns et al., 2014; Dillenbourg, 2007; Jones and Vall, 2014; OECD, 2013). Collaboration is a process of functional interdependence that aims to coordinate skills, tools and rewards.

Synergy learning model and traditional learning model are two different approaches in education process. Traditional learning models often focus on one-way teaching from teachers to students, while synergy learning models emphasize collaboration, interaction and active involvement of students in the learning process. In the Synergy Learning model, research shows that it often results in better understanding and higher retention of information. For example, a study by Johnson et al. (2021) found that students who studied in groups with a synergy approach showed significant improvement in test scores compared to those who studied traditionally. Meanwhile, the Traditional Learning Model, while still effective in some contexts, is often less able to facilitate deep understanding. A study by Smith (2022) showed that students who engaged in traditional learning tended to have lower results in conceptual understanding tests.

Then, based on student engagement, synergistic learning models show that this approach increases student engagement. Students who engaged in collaborative learning were more active in class discussions and showed greater interest in the subject matter. Traditional Learning Model: In this context, student engagement tends to be lower. The students in traditional settings are often passive and participate less in learning. From the impact on learning outcomes, this Synergy Learning Model shows that student learning outcomes in this model tend to be better. A longitudinal study by Kim (2023) showed that students who engaged in synergy learning not only gained better knowledge but also higher critical thinking skills. Traditional Learning Model, learning outcomes obtained through this model are often limited to factual knowledge.

Based on the findings of several studies, the application of collaborative solutions improves learning outcomes for Physics students. Faniashi et al. (2023) investigated the impact of a collaborative learning model based on science, technology, engineering, and math (STEM) on cognitive Physics student learning outcomes. Further, students can improve learning outcomes while also taking an active role in learning, such as collaborating by forming groups of friends and teaching children in science, technology, engineering, and math. A recent study by Ningsih (2023) found that project-based collaborative learning can significantly improve student learning outcomes. This improvement can be observed in a variety of ways, including improving the criteria for activity, rank, and percentage of learning intensity.

Based on the explanation of the collaborative-based synergy learning model also known as the multi-representative approach, it is a learning model that emphasizes the formation of heterogeneous groups where members interact, collaborate, and exchange information to solve common problems presented in various representations such as words, pictures, symbols, graphs, and diagrams. Therefore, this research aimed at developing Synergy Learning Model for Science learning specifically for Islamic junior high school.

2. Materials and methods

The data in the study came from various sources, namely classroom observation through direct observation in the classroom during the application of both learning models. It focuses on student interaction, engagement, and group dynamics. In addition, interviews with students and teachers were conducted to gain a more in-depth perspective of their experiences. Then, academic grades and exam results were analyzed before and after the implementation of the learning models. This data provides a more objective picture of material mastery. Student selection was done based on the same grade level to ensure consistency in the learning experience. In addition, the variation of academic ability is also the basis of student selection including students with various academic abilities (high, medium, low) to gain a broader perspective.

This study used the research development methodology proposed by Borg and Gall (2003). This method is used to create and validate educational processes. The process is initiated by reviewing research findings on the product to be developed and then developing the product based on the findings. Then, the field tests are conducted to test the product and correct any errors found. The Synergy learning model is developed according to the results of theoretical studies and field research on implementing scientific learning. The components used refer to the approach as a learning model development design, namely: (1) Initial investigation, a process to identify the characteristics of learning needs and analyze input behavior; (2) Learning design, a process to develop components and subcomponents of learning products; (3) Learning design results, a process to evaluate ongoing learning products and (4) modification, a process to modify each subcomponent. The design of Synergy Learning Model is shown in **Figure 1**.

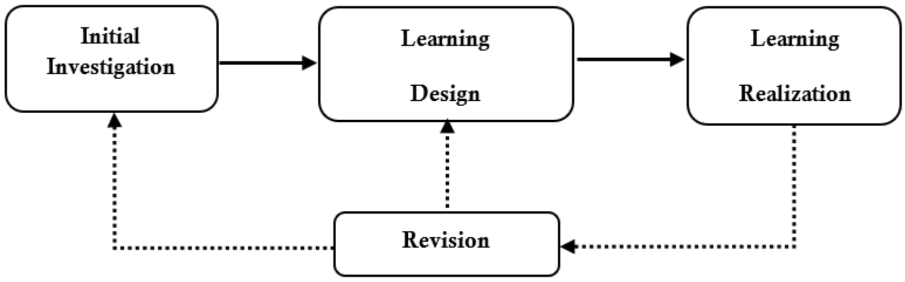

Figure 1. Research and development design of synergy learning model.

In the initial stage, researchers conducted a comprehensive needs analysis. The second step is to conduct a learning analysis. The third step involves analyzing the learners and the learning context. In the fourth step, the researcher develops learning objectives based on the analysis conducted in the previous steps. In the fifth step, measurement instruments are developed. In the sixth step, the researcher starts to develop learning strategies. In the seventh step, researchers select learning materials, which can be electronic and printed. The eighth stage is the design and implementation of formative tests. In the ninth stage, based on the formative test results, the learning is improved. The last step in the process is the summative test.

The data collection methods and instruments of this research include non-testing and testing methods. Non-testing procedures were employed to assess the feasibility of the learning model. (1) feasibility sheets were created using data from learning design experts, teaching material experts, media experts, and test subjects (students), and (2) observation sheets to see the practicality of implementing the developed Synergy learning model. While the test technique is also used to test the effectiveness of learning by taking learning outcome test instruments in the form of multiple-choice questions that measure the achievement of students' learning outcomes in the cognitive domain.

The instrument for model feasibility is in the form of a checklist sheet with alternative answers ranging from 1–4. The scoring criteria are: (1) score four states the situation is very precise, very appropriate, very clear, very good, very interesting, and very effective; (2) Score three states the situation is appropriate, appropriate, clear, good, interesting, effective, (3) score 2 states the situation is less precise, less appropriate, less clear, less good, less interesting, less effective, and (4) score one states the situation is not appropriate, not appropriate, not clear, not good, not interesting, not effective. Feasibility is measured from the model book, teacher book, student book, and textbook. Meanwhile, the instrument used to measure the effectiveness of the learning model is a learning outcome test. In this case, the learning outcome test instrument is prepared using a multiple-choice objective test totaling 40 questions with four answer options, namely, A, B, C, and D. Each test item has a weight for the correct answer choice is 1, and the wrong answer choice is 0.

The research instrument for the feasibility and practicality of the Synergy learning model is a validation sheet. In this case, testing the validity of the feasibility and practicality of the Synergy learning model instrument focuses on testing content validity to ensure that the items selected as instruments provide an acceptable scope of content to measure the characteristics of what will be measured. Research instruments used in developing learning models are assessed for feasibility by experts as validators. The feasibility of each instrument is seen from four aspects of the criteria, namely: (1) instructions, (2) material/content, (3) construction, and (4) language. Furthermore, testing the feasibility of the assessment instrument using Aiken's formula as in Equation (1).

$$\mathrm{V} = \frac{\sum s}{N\ (c\ -\ 1)} \tag{1}$$

Description:
V = validity index
$s = r - \mathrm{lo}$
N = rater
c = highest assessment number
lo = lowest assessment number $_{\mathrm{p}}$

The research instrument for the effectiveness of the learning model used is the learning outcomes test, so in this case testing the validity of the learning outcomes test point biserial correlation. The criteria are valid if $r_{\mathrm{count}} > r_{\mathrm{table}}$ at the real level $\alpha = 0.05$. The point biserial correlation formula as revealed by Surapranata (2004) is as in Equation (2).

$$r_{bis} = \frac{M_p - M_t}{SD}\, x \sqrt{\frac{p}{q}} \tag{2}$$

Description:
r_{bis} = Point biserial correlation coefficient
M_{p} = average score on the test
M_{t} = mean total score.
S_{t} = Standard deviation of the total score
p = proportion of learners whose answer is correct
$q = 1 - p$

Testing the reliability of the learning outcomes test instrument was analyzed using the Kuder Richardson technique (KR-21). The KR-21 formula to test the reliability of the learning outcomes test is used, as in Equation (3).

$$r_{11} = \left(\frac{n}{n\ -\ 1}\right)\left(1\ -\ \frac{M(n\ -\ M)}{nS_t^2}\right) \tag{3}$$

Description:
$r11$ = instrument reliability
n = number of items
M = mean / average score
S = total variance

3. Results and discussion

The design of the Synergy learning model is the development of a learning model based on the syntax of problem-based learning models, inquiry-based learning models, discovery learning models, and project-based learning models. The novelty of the developed learning model is based on the elaboration of four learning models. The syntaxes of the Synergy learning model are; 1) problem orientation, 2) organizing learning, 3) formulating and designing hypotheses, 4) conducting research to obtain data, 5) data collection and analysis of testing results, and 6) making conclusions. The development of the Synergy learning model includes three aspects of the process: planning, implementation, and learning impact.

Figure 2 presented the learning model structure of the development of the Synergy learning model. In the planning stage, needs analysis and curriculum preparation of learning outcomes and learning objectives are carried out. The implementation stage, which consists of the design of syntax components, social systems, principles of recreation, and support systems, is the learning impact stage. Meanwhile, the learning impact stage consists of instructional impact and accompanying impact. The learning impact of the development of the Synergy learning model includes two things: instructional impact and accompanying impact. Instructional impact is the learning outcome that students directly achieve by fulfilling the expected objectives, and the accompanying impact is other learning consequences arising from the learning process as a result of creating a learning environment directly faced by students. Teachers guide students. The development of the Synergy paradigm results in providing learning resources such as model books, teacher books, student books, and textbooks. After developing the model, the experts assessed the learning tools used. The average score of the eligibility assessment by the experts is shown in **Table 1** and the recapitulation of the results of the field test of the eligibility of learning device products is shown in **Table 2**.

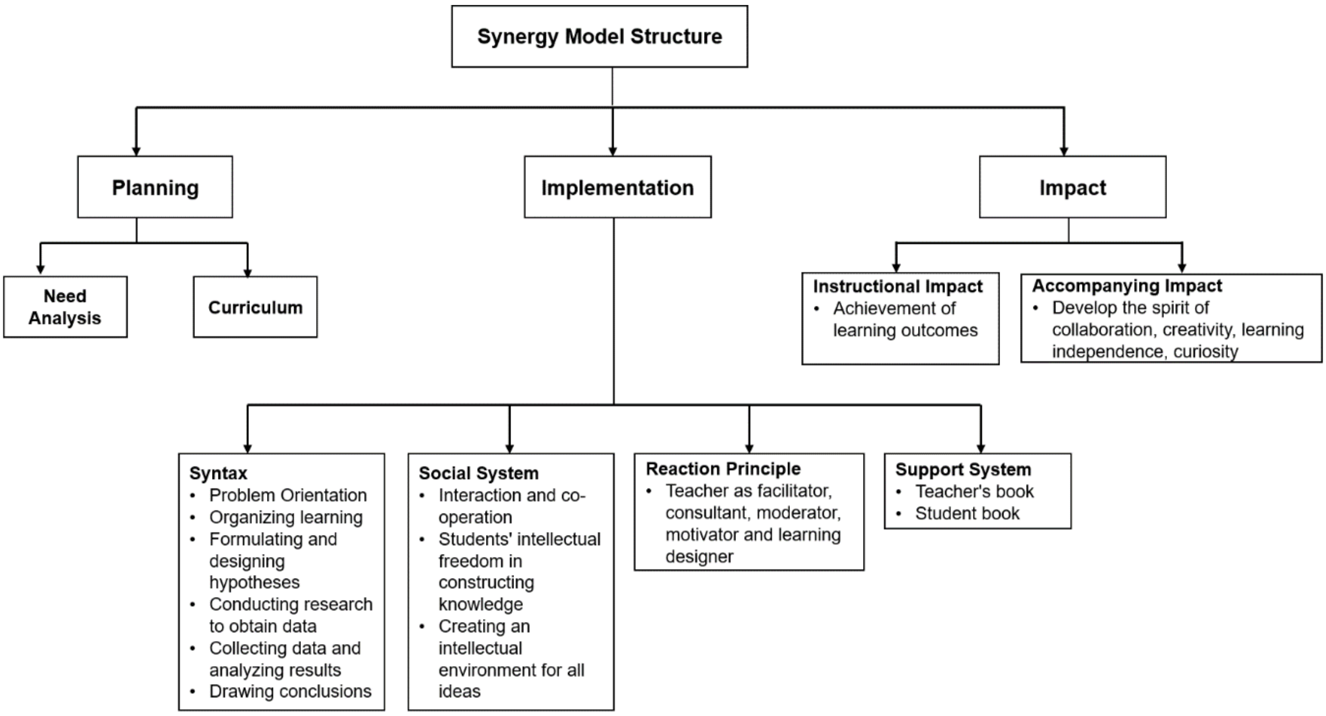

Figure 2. The structure of the synergy learning model.

Table 1. Recapitulation of average scores for learning material eligibility assessment.

Product Name	Average Score	Category
Synergy Learning Model Book	3.61	Eligible
Teacher's Book	3.52	Eligible
Student Book	3.62	Eligible
Textbook	3.62	Eligible

Table 2. Recapitulation of field test results for the eligibility of learning device products.

Trial Test	Average Score	Category
One-to-one learner test	0.86	Highly Eligible
Small group	0.83	Highly Eligible
Field trial	0.87	Highly Eligible
Average Score	0.85	Highly Eligible

Based on the results of the product eligibility test assessed by experts and the eligibility test of the learning tools in the field, it is considered eligible to be used. The validity of this instrument is useful for assessing or determining whether a product is suitable for development by asking experts or specialists to act as validators. In this regard, there is no research report that examines the effect of the four scientific learning models simultaneously on students' collaboration skills. However, many previous studies have been conducted one by one such as problem-based learning and project-based learning which are reported to be able to improve critical thinking skills and increase collaboration between students. (Dewi et al., 2016; Hayatin et al., 2018; Winata, 2020).

In order to measure the effectiveness of the learning outcomes with the developed model, this study measures by comparing the learning outcomes of students taught with the Synergy model and students taught with the expository model. Frequency data of student learning outcomes taught with the Synergy collaborative learning Model is shown in **Table 3**.

Table 3. distribution of student learning outcomes data taught with the synergy model.

Interval Class	$F_{absolute}$	$F_{relative}$ (%)
60–65	4	12.5
66–71	6	18.75
72–77	10	31.25
78–83	5	15.63
84–89	4	12.5
90–95	3	9.37
Total	32	100

The table shows that the majority of students taught with the synergy model achieved good grades, with most being in the middle to upper grade levels. This demonstrates that the model was effective in supporting most students to achieve adequate understanding of the material, while only a few students scored very high or very low. The histogram graph of student learning outcomes data taught with the Synergy learning model presented in **Figure 3**.

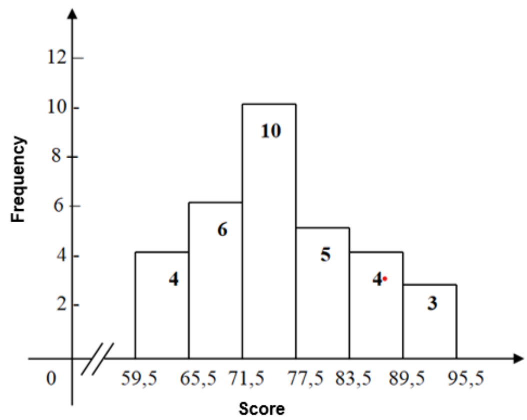

Figure 3. Histogram of student learning outcomes taught with the synergy learning model.

The findings from the histogram of the data on the learning outcomes of students taught with the Synergy learning model revealed that the average score of students was 76.00, signifying that most students scored quite good. Then, the results of this study were compared with the learning outcomes of students taught with the expository learning model. The frequency distribution of data on student learning outcomes taught using the expository learning model can be seen in **Table 4**.

Table 4. Distribution of student learning outcomes data taught with the expository learning model.

Interval Class	$F_{absolute}$	$F_{relative}$ (%)
50–55	3	9.37
56–61	6	18.75
62–67	9	28.13
68–73	6	18.75
74–79	5	15.63
80–85	3	9.37
Total	32	100

The results of this study show feedback from students feeling more excited to learn because they can discuss with friends. Learning becomes more fun. By working in groups, students understand difficult concepts. Sometimes, friends' explanations are easier to understand than the teacher. Meanwhile, feedback from teachers stated that students were more active and dared to ask questions when they worked in groups. This improved classroom dynamics. Students showed significant development in communication and collaboration skills. They are better able to work together on projects. With the synergy model, I see many students who previously struggled are now able to understand the material better.

Table 4 shows the learning outcomes of students taught with the Expository Learning Model. The data shows that the average student is in the interval 62–67. This indicates that the Expository Learning Model provides moderate results for many students but does not significantly improve student scores. In addition, the result of students leaning outcomes is shown in histogram in **Figure 4**.

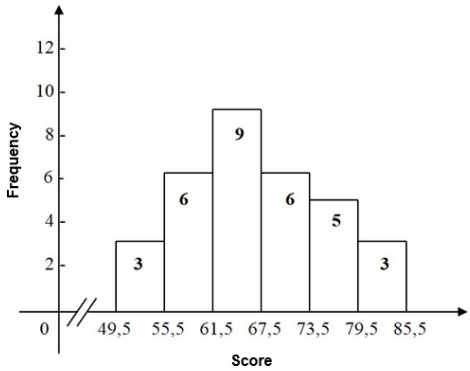

Figure 4. Histogram of student learning outcomes taught with the expository learning model.

Figure 4 showed the findings from the histogram of learning outcomes data of students taught with the expository learning. The average score of students is 66.93, It indicates that the Synergy learning model tends to produce better and more consistent learning outcomes compared to the Expository learning model. The students taught with the Synergy model had higher mean scores. This indicates that the Synergy model is more effective in improving students' understanding and learning outcomes compared to the Expository model.

Data from the assessment of the practicality of the Synergy collaborative learning model is obtained from the assessment of raters (assessors) who assess the implementation of the learning model, including syntax, social systems, and reaction principles. In this case, the rater made two observations. The results of the model's practicality were obtained by comparing the rating results from the first and second observations, as in **Table 5**.

Table 5. Recapitulation of the rating score on the observation of learning implementation.

Component	**Observation**		**Category**
	1	**2**	
Syntax	3.00	3.40	Practical
Social System	3.00	3.50	Practical
Management reaction principle	3.10	3.30	Practical
Average Score	3.05	3.40	Practical

The data above shows that the practicality score for applying the Synergy learning model increases from the first observation to the second observation. This score is based on the teacher's ability to consistently apply the Synergy learning model in implementing science learning in the classroom. The effectiveness of the Synergy learning model is assessed using learning outcomes, student activities, and teacher activities. To determine the success of the Synergy learning model in terms of learning outcomes, the learning outcomes of students taught using the synergy learning model will be compared with those learned using the expository learning model. The statistical test results show that $t_{\text{count}} = 4.26$ while the t_{table} price at $\alpha = 0.05$ is 1.99. Because the t_{count} price > t_{table} price, Ho is rejected. The price table is $\alpha = 0.05$, which is 1.99. Since the price of $t_{\text{count}} > t_{\text{table}}$, Ho is rejected, which implies that the Synergy learning model significantly impacts student learning outcomes.

4. Discussion

Science education often focuses on mastering facts and information, and underemphasizes the development of critical and creative thinking skills. The results of the study may trigger curriculum changes to include more inquiry-based projects and problem-based learning that encourage critical thinking. Furthermore, many students, especially in remote or disadvantaged areas, do not have adequate access to science education resources, such as laboratories, lab kits and the internet. Research could encourage the development of programs that provide science education resources online or through community initiatives to bridge this gap. Many students show low interest in science, which may result in low participation in advanced science programs. Research can help formulate strategies to increase student interest, such as project-based learning or collaboration with scientists and professionals in the science field. Information and communication technology is growing, many teachers still struggle to integrate technology effectively in science teaching. This research can provide insights for better teacher training on the use of technology in learning, as well as curriculum development that integrates digital tools.

Based on a series of learning activities carried out by students in the classroom using the synergy model in this study, it is able to encourage students to conclude findings from the data collection and experimentation process and communicate these findings to classmates. This is in line with the research of Fatimah et al. (2018) who explained that collaborative learning helps slow students in groups to learn together. The learning activities further encourage students to hone their problem-solving skills together (Barkley et al., 2016). The cooperation model used in this study is the ability to coordinate and work with students who have specific skills, as well as develop, manage, and evaluate programs together to achieve common goals with a high degree of interdependence. (Burns, et al., 2014; Dillenbourg 2007; Jones and Vall, 2014; OECD, 2013).

The Synergy learning model is inspired by a variety of learning models designed to be applied collaboratively by students in science learning. Related to this, collaborative learning is an excellent solution to the problem of facilitating interaction, group learning, and mutual support. The use of collaborative learning environments in science education. The use of collaborative learning environments can increase student participation, concept understanding, and cooperation skills in science learning (Järvenoja et al., 2020).

Collaborative learning models can be applied in a variety of environments by considering the local context and specific needs (Rachman et al., 2022). Through teacher training, use of technology, design of relevant activities and collaboration with communities, teachers can create more inclusive and effective learning experiences for students. Encourage students to work in groups to solve real problems faced in their communities. This increases engagement and relevance of learning. Organizing activities outside the classroom, such as visits to local places, to provide real context and integrate hands-on experiences into learning. With these strategies, collaborative learning becomes not only a teaching method, but also a way to build social skills and responsibility among students (Mei et al., 2023).

The results of this study may encourage educators to adopt synergistic learning models, which are proven to increase student engagement and understanding. By prioritizing interaction and collaboration, students can develop critical skills needed in the real world. Schools can design curricula that emphasize cooperation and communication skills. Strong social skills will prepare students to contribute effectively in society and the work environment. Educators can integrate a variety of learning methods that are more flexible and responsive to student needs. Adopting a more adaptive approach will enhance students' ability to learn independently and think critically. Training and professional development for teachers needs to focus on innovative and collaborative teaching methods. Teachers who are skilled in a variety of learning approaches will be better able to meet the needs of diverse students.

Despite the reported validation results, the limitations of this study need to be considered. The Synergy learning model developed has tools including model books, teacher books, student books, and textbooks designed in printed form; in this case, printed learning materials have limitations related to the presentation of linear material, so they tend to be used passively. The limited depth and breadth of the presentation of learning materials contained in textbooks is a factor of concern. Therefore, teachers and students can use other learning resources to complement each other and make students' knowledge more comprehensive. This research was limited to a limited test subject at one madrasah tsanawiyah, so it cannot be generalized to a wider scope. Therefore, it is necessary to add a wider range of subjects.

5. Conclusion

The results of this study prove that the Synergy learning model developed is effective in improving student learning outcomes. The use of the Synergy learning model can not only be used in science learning, but also in various scientific fields. This is because the design of the Synergy learning model is based on the results of theoretical studies and field research on the implementation of scientific learning. The application of the synergy learning model developed follows the syntax, which shows that this model is feasible to use in science learning, which has previously gone through a series of trials and assessments from several experts. The findings indicate that the Synergy learning model has the potential to significantly impact educational practices in Indonesia. It can be recommended to be implemented in various schools in Indonesia. Training and socialization need to be carried out so that teachers are familiar with the synergy model as one of the learning models that can be applied in learning activities. Empowering educators with this knowledge will enable them to create more dynamic and effective learning experiences for their students. In addition, further research can be conducted to compare more learning models to find out their advantages and disadvantages.

Author contributions: Conceptualization, Hd and HS; Methodology: Hd; software, RM; validation, HS and RM; formal analysis, Hd; investigation, Hd; resources, Hd; data curation, Hd; writing—original draft preparation, Hd; writing—review and editing, HS; visualization, Hd; supervision, HS; project administration, Hd; funding acquisition, Hd. All authors have read and agreed to the published version of the manuscript.

Conflict of interest: The authors declare no conflict of interest.

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