
Identifiying Students' Interest in Inheritance of Traits and Breeding of Living Things to Support Educational Sustainable Development

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Abstract.

The genetic strategy, namely the inheritance of traits and breeding of living things, is a complex material at the secondary school level. The difficulty of understanding the material is due to the absence of discussion of this material at the elementary school level and the use of science terms that students rarely hear. This study aims to determine students' interest in the material inheritance of traits and reproduction of living things, methods and learning resources used, and students' ability to identify the material inheritance of traits and reproduction of living things using indicators of reading ability. The method used in this research is quantitative-qualitative to see junior high school students' interest and identification results. Researchers used data from statistical analysis and interviews with students. Data analysis was done by reducing, presenting, and drawing conclusions. The results showed that interactive and varied learning resources, methods, and models can influence students' interests and learning outcomes. Interactive learning models can improve student learning outcomes in the material of inheritance of traits and breeding of living things and help students understand the concept of sustainable development.

Keywords: Breeding of Living Things, Educational for Sustainable Development, Inheritance of Traits.

Introduction

Trait inheritance is a law of separation discovered by G. J. Mendel in 1865. The law of trait inheritance discusses the factors controlling each trait that will separate during gamete formation. Factors that can determine different characters during the inheritance of traits are called genes. The study that discusses the inheritance of these traits is known as genetics. Researchers carry out the development of this science through crosses to reveal the pattern of Inherited traits. The material inheritance of traits, one of which discusses the breeding of living things (plants and animals). The availability of genetic material will affect the successful assembly of superior varieties that can increase the diversity of living things. In plant breeding, the availability of genetic material in germplasm can help improve the expected selection achievements (Pasaribu, et al., 2022). The inheritance of superior traits will also affect animal breeding. For example, they were breeding animals to produce varied livestock (traits and characters) with high quality and increasing the diversity of living things. Trait inheritance material is problematic in biology subjects at the junior high school level. Some junior high school students still need help to

learn trait inheritance material because it has extensive sub-materials with terms that are difficult to understand (Hidayati, et al., 2022). Meanwhile, several studies have revealed that varied natural conditions with high biodiversity can increase people's well-being and are essential for sustainable development (Rahman, 2022). Students' difficulties in learning the material of inheritance of traits and plant breeding are triggered by several factors, such as students' learning styles, the choice of learning methods applied, and the learning media used (Maharani & Lisdiana, 2023).

Studies show that genetics is complex and poorly understood by secondary school students in the UK (Dairianathan & Subramaniam, 2011). According to research conducted on junior high school ninth graders in one of the junior high schools in Jember, students said that genetic material and inheritance of traits were the most challenging material in biology lessons. They need help contextually relating learning concepts to everyday life (Hidayati, et al., 2022). Meanwhile, in another study, it was found that out of a sample of 131 students, none could meet the minimum passing criteria (KKM). This research shows that students need help understanding Mandel's law material (Maharani & Lisdiana, 2023). The number of misconceptions on the material of inheritance of traits is because high school students misunderstand genetic literature, which contains expressions that are difficult to understand and are abstract (Fajri, et al., 2022), on the concept of chromosomes and the crossing terms of phenotype and genotype (Agathe, et al., 2023; Hala, et al., 2018).

Knowledge of genetic material contains sub-concepts of molecules that underlie the inheritance of traits, the law of Inheritance of traits, and the breeding of living things. According to the research, the highest misconceptions among class XII students were in the mutation subconcept, 3.33%, and the inheritance of traits, at 35.57% (Fajri, et al., 2022). In a study conducted in Germany, students were unable to provide definitive clarity on genes, DNA, and chromosomes. In addition, there needs to be a greater understanding of the information, knowledge, and data related to the relationship between genes, DNA, and chromosomes, and this is used to help differentiate in understanding the inheritance of traits (Ball, 2023). Students conclude that all cells of the same type will contain the same genetic information, and all cells of different types will contain different genetic information. Students' understanding of genetic material cannot be separated from the everyday concept of "alternative conception" (Lewis & Kattmann, 2004). Teachers in Finland emphasize teaching the structure and function of genes, the DNA-evolution connection, and the phenotype-genotype relationship (Aivelo & Uitto, 2021).

An extensive international survey conducted by the Program for International Student Assessments (PISA) shows that male students are more interested in science and technology than female students, and also valid for students' interest in gene technology (Aivelo & Uitto, 2021). The importance of learning and knowledge about genetics with one of the gene technologies, namely genetic engineering, intending to breed living things (animals and plants). Meanwhile, previous research found that public knowledge about genetics still needs to be improved and expanded (Aivelo & Uitto, 2021).

For high school students aged 16-19, teaching approaches and learning materials influence their attitudes towards genetics and socio-scientific issues around them and influence the learning of genetics with technology. In addition to the content presented in learning, students' interests can influence their perspectives on how students are interested in genetics learning and contextualizing it (Aivelo & Uitto, 2021). Attitude is a direct change and adjustment to objects, events, and people in the surrounding environment. Student interest is a direct feeling directed toward objects, events, and fields of science to channel their high curiosity about something (Hidayati, et al., 2022), in this case, "inheritance of traits and breeding of living things." So, an interesting question is how students' interest in learning the inheritance of traits and breeding of living things correlates with the low

knowledge students have about genetics or the need for more utilization of learning support media.

There is a positive relationship between knowledge and attitude towards science (Aivelo & Uitto, 2021). Furthermore, it applies to the inheritance of traits and breeding of living things. Despite people's experience regarding the inheritance of traits and breeding of living things, they have a positive attitude towards genetics-related technologies (Aivelo & Uitto, 2021). Students' knowledge can be built on one of them through experience and learning associated with concrete life values. In addition, attitudes and ethics toward genetic technology must be learned by students in order to make the right decisions.

The selection of learning methods and media can develop and help students express the potential that exists in themselves (Maharani & Lisdiana, 2023). Contextual learning in genetic material with the context of complex human nature can build students' understanding. The more often students participate in outdoor education, the more they will like biology, and those who often learn biology learning will be more interested in biology material (Thaibah, 2021). There is a potential relationship between the teaching emphasis, the teaching materials applied, and students' conceptions of genetics materials. In Finland, the teaching provided by teachers, ranging from the use of methods, the utilization of learning media, teacher knowledge, and the ability of teachers to deliver material, dramatically influences the ability of elementary school students and junior high school students to understand biological material (Aivelo & Uitto, 2021), as well as genetics. Thus, the impact of biology teachers is most visible in elementary and junior high school students.

A person's sense of interest in something, and the stronger the relationship between a person and something, the greater the interest. Students will express interest in something by showing their participation in an activity. Interest greatly influences student learning activities, creates attitudes, and strengthens understanding of lessons. Increased learning interest can increase students' thinking about how the material is essential to learn and apply and how the material can be connected to other subjects (Ananda & Hayati, 2020). Without a high interest in learning, the average student is less able to answer correctly to the evaluation questions given, so the scores they achieve are less than satisfactory. Students' interest in learning affects their feelings of liking the material and the need for the material. With this interest, they will think and act for their future, one of which is sustainable development (Harahap, et al., 2022). One factor that influences students' interest in learning is internal factors in the form of cognitive psychological factors that can connect, assess and consider an event. Nelson Mandela said, "*Education is the most powerful weapon with which you can change the world*". Students with cognitive abilities can know and understand knowledge about the environment which can ultimately analyze a phenomenon.

Student interest is derived from cognitive abilities, one of which contains behaviour, hot-to-knowledge, where students can use an innovation appropriately in a change in this context, sustainable development. The innovation of sustainable development theory leads to changes in behaviour for the better, oriented towards the present and the future. Its application requires the role of learning, assistance, infrastructure, and commitment of an educational institution. Thus, students can learn about the impact of environmental damage caused and the risks faced if the damage continues (Prabawani, 2021).

Inheritance of traits is the transfer of traits from parents to offspring, passed down through male and female sex cells containing DNA and RNA. Breeding of living things is an activity that changes the genetic makeup within a species with the aim of breeding by producing many superior varieties. Both of these materials, inheritance of traits, and breeding of these creatures are discussed in one material, namely genetics. The breeding

of living things will produce genetic diversity, species, and ecosystems that are useful and play an essential role in sustainable development. Sustainable development issues emphasize natural science learning, namely conservation efforts (Kopnina, 2012; Hasslöf, et al., 2016). Many high school students have difficulty understanding genetic material regarding the inheritance of traits and plant breeding—using terms that are difficult for students to understand because they are abstract. Genetic literature contains expressions that are difficult for students to understand. These terms are growing over time, accompanied by many discoveries in the field but not accompanied by the development of books as sources and teaching materials for learning. In addition, students' interest in gene technology is lacking. Students' success in understanding genetics plays a vital role in understanding and applying sustainable development efforts. However, many schools have not implemented sustainable development-based learning. As a result, many students do not practice sustainability attitudes because their understanding is only limited to the emotional order (Aina, et al., 2023). 21st-century learning requires students to engage their knowledge and knowledge of environmental problems. This knowledge is helpful to help students in addressing environmental problems and help them to foster an attitude of environmental care (Rahmah, et al., 2021; Maghribi & Sidiq, 2023). Sustainability is a priority of 21st-century society worldwide; the existence of learning that implements sustainable development is a follow-up to the millennium development towards the ideal to improve current living conditions. The level of ESD implementation is not always successful and easy to implement because it needs to be adjusted to the goals, so it is necessary to implement local issues to help achieve ESD (Amprazis & Papadopoulou, 2020).

Specifically, this study investigated the extent of students' understanding of sustainable development through the inheritance of traits and breeding of living things at the secondary school level. Identifying students' interest and ability in identifying the material inheritance of traits and breeding of living things after students are given treatment using several methods and approaches in learning. In addition, the novelty of this research is that it is essential to identify the extent to which students can know the relationship and implications of the material on education for sustainable development, as well as knowing the effect of using learning models on the results of student interest and identification. Given that education for sustainable development is very important, we would like to see a broader perspective on whether student interest in learning methods and resources can improve learning outcomes in the form of student understanding of the inheritance of traits and breeding of living things with implications for education for sustainable development.

The following are students' views on genetic material and gene technology in the form of inheritance of traits and breeding of living things—the difficulties students face in learning genetic material. Therefore, this study aims to identify and determine students' interest in the material inheritance of traits and the breeding of living things, as well as the importance of the inheritance of traits and breeding of living things for sustainable development. The results of previous research described above gave rise to two research questions 1) How is students' interest in learning the material of inheritance of traits and breeding of living things, 2) How can learning resources be efficiently used as material delivery in increasing student interest in the material inheritance of traits, breeding of living things, and understanding the concept of education for sustainable development, 3) What learning methods and models are most efficient to help students understand the concept and integrate the material of inheritance of traits and sustainable development in everyday life (Ibourk, et al., 2018)

The focus is on the efficiency of learning resources and learning methods as an increase in junior high school student's interest in learning the material of inheritance of traits and breeding of living things with a sustainable development approach. The results are expected to be a development of teaching genetic material, especially the inheritance of traits and breeding of living things, in terms of methods, sources, and learning approaches applied. In addition, the results of identifying the effect of student interest on learning outcomes are used to determine how students can understand the inheritance of traits and breeding of living things and know the importance of implications in education for sustainable development.

Methods

The type of research used is a mixed method (quantitative-qualitative), which is analyzed descriptively. The combination of quantitative and qualitative methods was used to get a comprehensive and broader picture of students' interest in learning genetic material of inheritance of traits and breeding of living things, as well as their knowledge of sustainable development. This study used participants, namely 30 students from class IX, who studied biodiversity, the inheritance of genetic material traits, and the breeding of living things. The majority of them were 12-15 years old. The sampling technique was stratified cluster random. Thus, they already represent a group of junior high school students. Data was collected in one of the junior high schools in Ponorogo Regency, which lasted 80 minutes or 2 lesson hours (JP) using one class as the control class.

Quantitative data were collected through tests and interviews with instruments in the form of test instruments and questionnaires. The test instrument was in the form of multiple choice post-test questions and descriptions that were assessed using adjusted reading ability indicators, namely the ability to understand the meaning of words, determine implied and explicit meaning, and make conclusions (Nuraini, 2019) on the topic of inheritance of traits including monohybrid and dihybrid crosses, breeding of animal and plant life, and the relationship between these two things with education for sustainable development. The questionnaire instrument was developed according to the student learning interest guideline, which contains student interest in learning resources and learning methods applied. The identification test of inheritance of traits and breeding of living things is carried out in the form of providing learning resources in the form of teaching modules that have been adapted to the educational sustainable development (ESD) approach, the internet, and student books that have been adapted to the curriculum currently used, namely the merdeka curriculum.

Qualitative data was collected using an interview instrument using interview guidelines relating to students' interest in learning resources, learning methods and students' knowledge of education for sustainable development. The results of qualitative data were taken and used to strengthen the quantitative data findings. The instrument's feasibility test was carried out by asking for advice from experts in the field being measured. After receiving suggestions and input, revisions were made to improve the instrument.

test between student learning outcomes and student interest using SmartPLS by conducting ANOVA tests. Furthermore, to see the significance level in hypothesis testing (f-Square) and testing hypotheses (t-Statistics) with the help of bootstrapping. Qualitative data in the form of interviews are presented as interview result codes to support quantitative data results. The results of this data calculation and analysis determine the sustainability of students' interest and learning outcomes in the inheritance of traits and breeding of living things after using learning resources and learning models they are interested in. In a study on student interest in learning, the strategies applied in learning, namely providing varied and visually and audiovisually interesting learning resources, can help attract student interest and attention (Febriani, et al., 2022)

Results and Discussion

The results show some differences between each student regarding their identification and thinking about the inheritance of traits and breeding of living things, students' interest in the crossing process, especially the crossing of living things through the mating process, their views on the relationship of breeding living things in sustainable development, and their sources of seeking information and knowledge related to the inheritance of traits and breeding of living things. Similarities were found in their views regarding interest in learning methods and learning resources used.

Interest in the Breeding of Living Things

Students were asked to rank their interest in breeding as very high, high, neutral, low, and very low. A person's general interest in the breeding of living things influences their interest in the inheritance of traits in living things. A total of (16%) of students had "very high" interest, (70%) of students had "high" interest, and (14%) of students had "average" interest, of which there are 6 students had a very high interest in breeding living things, and 21 students have a high interest, so it can be seen that no one has a meager interest. Having a high interest in student learning is one of the factors that can improve students' ability to increase students' thinking power and learning activities (Ananda & Hayati, 2020). Interest is the most critical factor in increasing student motivation and learning activities, so interest is an important thing that must be owned by students and built by teachers (Awe & Benge, 2017).

Identification and Interest in Trait Inheritance and Breeding of Living Things

The identification of inheritance of traits by students was tested using questions in the form of story problems in the aspect of reading ability with indicators of capturing word meaning and meaning for all students. Students' ability to identify the inheritance of traits still needs to improve. Only (46%) were able to identify the inheritance of traits well on the indicator of capturing the meaning of the word "inheritance of traits" and the meaning in identifying factors that affect the inheritance of traits, (23%) students had a low ability to identify on the indicator of capturing the meaning of the word being able to identify what the inheritance of traits is. The rest needed to improve their ability to identify the inheritance of traits. Many students still need help knowing genetic information and variations in the inheritance of traits. Non-normative views and inappropriate scientific ideas make it difficult for them to understand the concepts of trait and genetic variation (Ibourk, et al., 2018) Meanwhile, students' ability to identify plant breeding is considered high. There were (60%) who were able to identify well on the indicator of making

conclusions, (30%) had moderate ability, and (10%) had low ability in identifying plant breeding.

According to the literature (Hidayati, et al., 2022), in learning Genetics material, namely crosses in the pattern of inheritance of traits, it is necessary to apply learning methods to develop genetics concepts in the form of inquiry methods that facilitate students to conduct experiments and solve problems, and inquiry methods are appropriate for application in science learning. Overall, 93% of students could identify the breeding of living things, but identification of inheritance of traits was still very low, namely in monohybrid crosses 60% and dihybrid crosses 43%. The scientific knowledge and alternative perspectives students have before learning about the inheritance of traits and plant breeding determine students' ability to identify the indicator of making conclusions (Dairianathan & Subramaniam, 2011).

Grade IX students have a low average (50%), and (50%) have a high average in identifying the inheritance of traits and breeding of living things using aspects of reading ability. Based on the reading ability indicators, on the inheritance of traits sub-material, there are two indicators that they can identify, namely one on the indicator of the ability to capture the meaning of words and one on the indicator of the ability to capture meaning. 15 students were able to identify correctly, 7 students were able to identify low, and the remaining 8 students had meager ability. Meanwhile, one indicator they can identify in the sub-material of breeding living things is the ability to conclude.

Student interest in trait inheritance and plant breeding does not correlate with test results. The minimum test score obtained by students is 1, and the maximum score obtained is 4 with 6 questions. After being tested based on the learning methods used by students in class with PBL (problem based learning) and learning cycle methods on student learning outcomes, there is no statistically significant effect given by learning methods on student learning outcomes ($t - statistic = 0.779$ and $p - value = 0.436$) with a $f - Square\ value = 0.054$ which means that student interest in learning methods has a weak influence on student learning outcomes. This low level of identification of grade IX students was tested using reading skills that have yet to reach those of previous researchers. Although they have been given treatment using different methods, the test results shown still need to be higher in identification. When students were asked about their interest in the learning methods used, according to the students, the most efficient teaching and learning method is problem-based learning. Students are given a problem related to genetics, and then they, together with their group mates, try to analyze and solve it. Interestingly, this finding does not correlate with other studies that observed applying PBL methods in learning to improve learning outcomes (Nainggolan, et al., 2023). In addition, by using the learning cycle method that gives students a problem without prior knowledge, there is also no positive relationship between student interest in the method used and student learning outcomes. The contributing factor is the incompatibility of the concept of the material taught with the method used, which should teach students first about the "concept." In addition, the lack of seriousness of students in filling out the tests and questionnaires given due to the limited time factor. According to other studies, genetics learning methods that use humans as learning objects can help build students' conceptual understanding of genetic material, especially crosses (Aivelo & Uitto, 2021; Bilal, 2021). However, there is a positive correlation between the method used in understanding the concept of the material used. A cognitive approach needs to be done to build students' understanding of the material inheritance of traits and the breeding of living things through a clear interpretation of a text to produce the correct answer. In addition, in another study, to increase students' interest and understanding of the material of inheritance of traits,

interactive learning is needed that involves individual students directly and can connect learning objectives directly to everyday life (Low & Ellefson, 2024).

Breeding of living things is better identified than inheritance of traits in the form of the meaning of inheritance of traits, factors, and laws of inheritance of traits. A total of (82%) of students had an interest in monohybrid crosses, and (82%) students had an interest in dihybrid crosses. It is known that students' interest in both materials is balanced, and last but not least, plant breeding (81%). Monohybrid and dihybrid crosses received the highest interest among ninth-grade students. Some students mentioned their interest in the material inheritance of traits in living things related to the law of monohybrid and dihybrid crosses.

Table 1. Student interest in inheritance of traits in living things (monohybrid and dihybrid)

Material	Percent (%)
Monohybrid	82
Dihybrid	82
Breeding of Living Thing	81

Students' interest in the inheritance of traits and breeding of living things comes from a view of environmental and educational concerns. This interest is explained as follows: From learning this material, we can care about the environment, and we can help preserve the environment. We know new knowledge (W1.S1). We can understand this material. To prevent extinction (W2.S2). Can make superior plants and animals. Knowing how to cross finally can make superior plants and animals with superior varieties (W3.S3).

Source of Information

Students were asked to fill out a questionnaire in the form of their interest in the sources of information they use to get information about the inheritance of traits and breeding of living things. Students have a high interest in teaching modules (70%), followed by the Internet (16%), and finally, student books (14%) (Table 2). At school, most of them get information about the inheritance of traits and breeding of living things through student books. When they are given innovative learning resources through teaching modules, their interest in learning through these sources is very high because they have never used teaching modules as learning resources before. Then followed by internet sources, and the last is student books because they are used to using student books as learning resources, so their interest is low.

As these results are intended to be central to the development of teaching and learning of trait inheritance and breeding in secondary schools, they were asked in more detail. Students chose the teaching module as the most effective and most important source they used to find information related to the inheritance of traits and breeding of living things. Most of them chose teaching modules and Internet media. The significant results obtained (t statistic = 2.617 and p – value = 0.007) said that the learning resources that students are interested in have a direct effect on student learning outcomes (Table 3).

Table 2. Learning resources that students choose to identify

Learning Resources	Percent (%)
Module	70
Internet	16
Student book	14

Table 3. Path Coefficients to test the relationship between Learning Resources and Learning Outcomes

	Original Sample	Sample Mean	Standart Deviation	T Statistics	P Values
Learning resource → Learning outcomes	-0.395	-0.456	0.147	2.690	0.007

The students explained the importance of learning by using more innovative resources than usual to attract students' attention and interest in learning. With this innovation, they hope to learn a lot about crosses with one different trait, two different traits, and efforts to breed plants and animals: they sometimes use the opportunity to ask questions given by the teacher (W1.S1), some of them also do not use the opportunity (W2.S2). However, some also argue that if they already know the material, there is no need to ask (W3.S3).

Students think that books are the most important source of learning material for interbreeding. In identifying the reproduction of living things, their source can come from the internet. They can utilize their free time and independent study at home to dig up the information using their reading skills. Students chose reading materials in the form of books as one of the most important sources of information - reported teaching modules (70%) and student books (14%). Learning outcomes that are pretty low on the indicator of reading ability in identifying the inheritance of traits and breeding of living things do not correlate with other studies, which state that learning media in the form of teaching modules are effectively used in improving student understanding of a concept of inheritance of traits and breeding of living things (Maharani & Lisdiana, 2023; Aivelo & Uitto, 2019). In addition, learning resources in the form of textbooks have a significant impact (Ariyansyah, et al., 2023), and also learning videos can increase student interest in participating in learning the inheritance of traits and breeding of living things (Febriani, et al., 2022), so that the variation in the use of learning resources is one of the factors determining student learning outcomes. The difference in results obtained with previous research is due to internal factors where students need more understanding in understanding the meaning of the post-test questions given and the questions used are at a challenging level. Student errors in interpreting questions, understanding the meaning, and drawing conclusions from questions influence student post-test results (Lee & Byun, 2022). Students' first experience learning the inheritance of traits and breeding of living things may also determine student learning outcomes regarding genetic material (Low & Ellefson, 2024).

The learning resources used are the most important for students to understand the material inheritance of traits and the breeding of living things. According to research conducted by (Kover & Hogge, 2017) the use of interactive and varied learning resources with consideration of their content is highly recommended so that students can obtain extensive information. However, this is different from the data obtained. The level of student identification and student understanding of the inheritance of traits and breeding of living things is still low, as evidenced by the low student learning outcomes around the number (30%) and based on the results of data analysis in Table 3 it is known that interest in learning resources has an indirect effect on student learning outcomes. The difference in this study's results was caused by students who needed to be more careful in their work, limited time, and students' lack of seriousness in working.

Teaching and Learning Method

PBL was emphasized by most students (51%) as the most efficient learning method, followed by experiential learning. The students were asked to complete a questionnaire ranking the level of favorability of the learning methods used. Students gave the highest rating to PBL out of the two learning methods used, PBL and learning cycle. PBL is very efficient for group investigation and group work in solving problems.

The students explained that the efficiency of the problem-based learning method is that they can use their analytical skills to solve problems in a working group. However, this efficiency sometimes must match their ability to learn outcomes using both methods. Another method is discovery learning.

PBL and learning cycles are two efficient methods to apply to this material. This method is explained: a suitable learning method is one where you can experience something, think with others in solving problems, and experiment (Palmberg, et al., 2015). Trait inheritance and breeding require problem-based methods to help them analyze and solve problems. When learning about the inheritance of traits, students need to be able to make crosses and know the efforts used in breeding living things.

Teaching, Learning, and Learning Materials

The students were asked to fill in a questionnaire with a score of 1 - 5 regarding the most efficient learning material to use. Monohybrid and dihybrid were ranked highest by most students (33% and 33%), followed by breeding of living things (32%). Then, students identified the inheritance of traits and reproduction of living things through learning modules (34%), the internet (34%), and student books (30%). The number of students who choose learning modules and the internet as their source of information about the inheritance of traits and breeding of living things because the appearance of the two learning resources is interactive and visually appealing. Learning modules containing interesting pictures and internet displays with many features and colors encourage extrinsic student motivation to love these two learning resources (Low & Ellefson, 2024) (Table 4).

Table 4. Efficient Teaching Materials ranked by students

Teaching materials	Percent (%)
Module	34
Internet	34
Student book	30

Identification Principles of Traits Inheritance and Breeding of Living Things

Teaching results using learning materials that students are interested in by the principles of identification of inheritance of traits and reproduction of living things. Students are asked to mention essential characteristics in the inheritance of traits and reproduction of living things in the form of crosses of one different trait, namely monohybrid, crosses of two different traits, namely dihybrid, and know the reproduction of living things in plants and animals. Students identify monohybrid, dihybrid, and crossbreeding plants and animals through teaching modules, the internet, and books. Based on the percentage of students' ability to identify, students can identify well on the material of crossing traits, namely monohybrid and dihybrid. In contrast, on the material of breeding, living things have a low percentage of 31%, but both do not show a significant difference. The lack of hands-on experiences, such as out-of-school visits that introduce students to open habitats and environments, makes students less able to explore their ideas about the concepts and characteristics of the inheritance of traits and breeding of living things (Dairianathan & Subramaniam, 2011) (Table 5).

Table 5. Materials to identify the inheritance of traits and breeding of living things (N = 30)

Materials	Percent (%)
Mohybrid	32
Dihybrid	32
Breeding of Living Things	31

Importance of Identification of Trait Inheritance and Breeding of Living Things in General

According to 60% of ninth graders, identification of the inheritance of traits and breeding of living things is essential. As many as 40% of ninth graders consider the identification of inheritance of traits and breeding of living things necessary. No one considers that identification is less important or even not influential at all. For class IX students, identification of the material is essential even though their identification results in the test are meager on the inheritance of traits and high on the breeding of living things.

The students argued about the importance of identifying the inheritance of traits and breeding of living things through learning at school and outside school. According to class IX students, maybe the book knows finally how to cross one different trait, two different traits and how plant breeding is (W1. S1), can understand the material inheritance of traits

and breeding of living things (W2. S2), Yes, you can do that, make superior plants and also animals with superior varieties (W3. S3).

The Importance of Trait Identification and Breeding for Sustainable Development

When they were asked about the importance of species identification for sustainable development, 56% of ninth graders answered very important and 44% answered important, and no one answered less critical or even unimportant in identifying the inheritance of traits and breeding of living things for sustainable development. The arguments expressed by students in viewing the identification of the inheritance of traits and the breeding of living things are essential. The following are their justifiable opinions regarding the importance of identification: learning this material may be able to care about the environment, can participate in preserving natural resources (W1. S1), to prevent extinction so that he can face evolution (W2. S2), so knowing what crossing is can finally make superior plants and animals that have superior varieties (W3. S3).

The Importance of Breeding for Sustainable Development

Based on the answers of class IX students, breeding hydro creatures, namely plants and animals, is related to sustainable development and is considered essential and even very important for sustainable development. Essential arguments are: learning this material may be able to care about the environment, participate in preserving natural resources (W1. S1), prevent extinction so that he can face evolution (W2. S2), and know what crossing finally can make superior plants and animals that have superior varieties (W3. S3).

There are contradictory things about this study, as mentioned, namely, these findings do not correlate with other studies. There is no correlation between the learning resources chosen by students and those that have been applied to student test results and no correlation between the methods used in the form of PBL and the learning cycle with student learning outcomes. This difference is due to several internal and external factors, such as the level of questions that are applied too tricky, the incompatibility in the selection of methods, the lack of seriousness of students, and the lack of working time. The importance of identifying the inheritance of traits for breeding living things, more explicitly contributing to sustainable development, is supported and emphasized by students. This is also supported by literature; according to (Sharma, et al., 2022), plant breeding in the form of genetic engineering helps the agricultural system adapt to global growth by accelerating the breeding of new varieties that can contribute to long-term sustainability. Students' lack of knowledge of the role of inheritance of traits and breeding of living things due to lack of practice, understanding of the material, teaching provided, and poor resources, such as teacher competence in understanding what ESD is, as well as resources supporting learning activities so that the implementation of educational sustainable development in schools is hampered (Kougias, et al., 2022). Students are only aware of the value of sustainability at an emotional level but need to practice it in everyday life. The low implementation of the responsibility of sustainability awareness is due to the need for more understanding of perceptions and concepts regarding the concept of educational sustainable development (Aina, et al., 2023). In addition, the rare application of educational sustainable development-based learning is a factor in the need for students' awareness of sustainability responsibility.

Some explanations have discussed student interest in science, which depends on the quality and type of teaching applied (Palmberg, et al., 2015; Ilhamsyah, 2022). Based on the research we have done, many experimental methods should still be tested to determine how much influence they have on the learning outcomes of the material of inheritance of

traits and breeding of living things. The teaching methods applied should be exciting and project-based learning. In addition, applied learning should include methods that provide direct experience to students (Hasslöf, et al., 2016). Furthermore, in applying learning with the aim that students can contribute and understand sustainable development, it is necessary to apply learning contextual to the environment while still looking at the context, situation, and circumstances of students and the school environment.

This research has implications that teachers must be able to strive to create a learning inheritance of traits and breeding of living things into fun learning, one of which can be through the application of learning models using an environmental approach and integrating it into everyday life. That way, it is helpful to improve students' cognitive abilities so that it can affect student interest in learning and increase student understanding.

Conclusion

The high interest of students in PBL methods and interactive learning resources is different from the learning outcomes they get on the material of inheritance of traits and reproduction of living things. Student learning outcomes in the form of the ability to identify material on inheritance of traits and reproduction of living things through reading ability indicators are at a low percentage, which is equal to (30%). Students' ability to identify and understand the material of inheritance of traits and breeding of living things using reading ability indicators is influenced by learning methods, learning resources, teaching materials, and student interest. Varied learning resources increase student interest in learning. Applying PBL methods by integrating them using varied learning resources provides an experience for students to think and integrate learning into everyday life.

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