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Analysis of Student's Initial Concept on Genetic Material in Pontianak City

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Abstract: This research aims to determine the initial concepts and knowledge source factors that have the greatest influence on student's understanding on genetic material in Pontianak City. This is a descriptive research with a quantitative approach. Samples are 90 second-grade students at State High Schools in Pontianak City. The instruments used were a diagnostic test consisting of 25 multiple choice questions and a Response Certainty Index (CRI) as well as a genetic knowledge source questionnaire. The test results are analyzed by categorizing students' conceptual understanding based on correct or incorrect answers and low or high CRI scores which are then grouped into understanding the concept, not understanding the concept, guessing, and misconceptions. Student answers showed that only 29% understood the concept, 27% did not understand, 12% guessed, and 32% had misconceptions. School teachers are the highest source of knowledge at 79%, and the study group is the lowest at 22%. The percentage of students who understand the concept is lower than students who do not understand, guess and experience misconceptions, so teachers must handle class XII optimally, for example by planning the best learning models and media to overcome the low understanding of genetic concepts among students at school.

Keywords: certainty of response index (CRI), genetics material, initial concept, student's understanding.

Abstrak: *Penelitian ini bertujuan untuk mengetahui konsep awal dan faktor sumber pengetahuan yang mempunyai pengaruh paling besar terhadap pemahaman siswa pada materi genetika di Kota Pontianak. Penelitian ini merupakan penelitian deskriptif dan menggunakan pendekatan kuantitatif. Sampel adalah 90 orang siswa SMA Negeri kelas XI di Kota Pontianak. Instrumen yang digunakan adalah tes diagnostik yang terdiri dari 25 soal dan Indeks Kepastian Respon (CRI) serta angket sumber pengetahuan genetik. Hasil tes dianalisis dengan mengkategorikan pemahaman konsep siswa berdasarkan jawaban benar atau salah dan nilai CRI rendah atau tinggi yang kemudian dikelompokkan menjadi memahami konsep, tidak memahami konsep, tebakan, dan miskonsepsi. Jawaban siswa menunjukkan bahwa hanya 29% yang memahami konsep, 27% tidak memahami, 12% menebak, dan 32% mengalami miskonsepsi. Guru sekolah merupakan sumber pengetahuan tertinggi sebesar 79%, dan kelompok belajar terendah sebesar 22%. Persentase siswa yang memahami konsep lebih rendah dibandingkan siswa yang tidak memahami, menebak-nebak, dan mengalami miskonsepsi sehingga guru harus menangani kelas XII secara maksimal, misalnya dengan merencanakan model dan media pembelajaran terbaik untuk mengatasi rendahnya pemahaman konsep genetik siswa di sekolah.*

Kata kunci: *certainty of response index (CRI), materi genetika, konsep awal, pemahaman siswa*

▪ INTRODUCTION

Biology learning requires understanding concepts, problem-solving skills, and high order thinking. Biology learning also requires creative, active, and independent thinking, because it contains many basic concepts related to life. Biological material also has a lot of text, meaning that to understand the material it is necessary to read the text well and systematically so that the terms and concepts contained in the material can be understood

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properly (Hasanah, Abdullah, & Sugianto, 2013). As mentioned by Lazarowitz & Penso (2010), difficulties faced by students regarding meaningful learning of biological concepts can be due to the biological level of organization and the abstract level of the concepts.

Educational evaluation can be interpreted as an action or a process to assess or measure everything related to education (Achadah, 2019). A good evaluation system will be able to provide an overview of the quality of learning to help teachers plan learning strategies. Evaluation can also measure factors such as situation, development of goals, abilities, and knowledge (Magdalena, Fauzi, & Putri, 2020). The initial concept of students is very important to be known by every teacher because in learning the initial understanding and level of the intellectual development of each person is different. Initial concept or initial knowledge is a collection of knowledge and experience owned by someone from various life experiences that are brought and used for an experience or new knowledge (Trianto, 2007). Thus, it is very important for teachers to understand these conditions by linking understanding and summarizing the different levels of students' abilities with explanations and various strategies to explain the correct concept (Arends, 2012).

One of the materials in biology that is difficult to understand not only for most secondary school but also university students is genetics (Johnstone and Mahmoud, 1980; Meilinda, 2009). This difficulty is because genetic material is esoteric and abstract, which includes microscopic objects and processes outside of students' everyday experiences (Herlanti, Rustaman, & Setiawan, 2007). Inaccurate and inconsistent information about basic genetic concepts makes it difficult for students to make connections between these concepts and cannot fully understand and explain the processes underlying genetic events. (Kılıç Mocan, 2021). Hidayat and Kasmirudin (2020) also confirmed that genetic material is difficult to understand because the concepts are difficult to apply in everyday life so students are not able to construct the genetic concept as a whole. This is also confirmed in the research of Flores, Tovar, & Gallegos (2003), Lewis and Wood-Robinson (2000), Marbach-Ad and Stavy (2000). They revealed many conceptual problems in primary and secondary education students related to cell biology and genetics. Whereas one of the goals of Science Education is to make students learn concepts as a whole and to make students able to use these concepts in everyday life (Keleş and Kefeli, 2010).

The results of research on understanding the initial concept of genetics conducted by Topçu and Şahin-Pekmez (2009) for secondary education students showed that only 14% of students could explain well the function of cells while regarding the function of chromosomes only 5% and about the function of genes 35%. Meanwhile, the explanation of DNA function was 57%. At the student level, research by Infante-Malachias et al. (2010) provide an illustration that about 15% of students cannot provide an explanation of chromosomes, and 70% provide an incorrect explanation of the processes of mitosis and meiosis. In addition, Topçu and Şahin-Pekmez (2009) stated that students have difficulty studying genetics in terms of material content, source books, learning methods, and genetic material related to mathematics. This shows that mastery of concepts is influenced by various factors. Tundugi (2008) revealed that misconceptions also occur among students in Palu City about the concept of chromosomes (76.1%), genes (75.0%) and DNA (76.5%), and protein synthesis (63.1%). Previous studies on student's conception on genetic material in Pontianak City also showed a relatively significant

percentage of misconception among high school students in Pontianak City (Maulidi, Ariyati, & Mardiyyaningsih, 2014; Waskito, Candramila, & Yokhebed, 2020).

Several factors can affect students' mastery of concepts, including weak basic knowledge of students (Tekkaya, 2002); lack of material deepening (Shaw et al., 2008); and missing the latest information related to the material. Based on the lack of in-depth material, Shaw et al. (2008) revealed that one of the ways that can affect student mastery is by leading efforts to study the material further or in depth about the study material. According to the above description, it is important to describe the student's initial concept of genetic material among second grade students in state high schools in Pontianak City. This research is also aimed at finding the knowledge source factor that has the greatest influence on the initial concept understanding among the students. It is hoped that this research will give basic information for teachers in designing the learning activities in genetic materials to increase the student's comprehension.

▪ METHOD

Research Design

This is descriptive research with a quantitative approach which is aimed is to explain the understanding of the initial concepts of class XI SMA students in Pontianak City on Genetic Materials and determine the factors that have the greatest influence in the form of percentages. The method used in this study is an exploratory survey method using a questionnaire and a diagnostic test as tools to explore real or actual phenomena.

Participants

The population and sample in this study were second grade students at state high schools in Pontianak City. We sampled 3 out of 11 state high schools randomly in which all schools in the population were given the same opportunity to be selected as sample members. Thirty respondents were collected from each school so in total there were 90 student participants.

Procedures

This research was carried out in three stages, namely preparation, implementation, and data analysis. In the preparation stage, the problem and research objectives are formulated, followed by a literature search to design test questions. We prepared a number of questions based on the basic competencies expected in third grade of high school on Genetics Material. At this stage we also determine the form of diagnostic test that will be used and the expected student response confidence. The diagnostic test is in the form of multiple choice with 25 questions and the certainty response index (CRI) is used to measure the confidence of students' answers. Next, the diagnostic test questions were validated by two genetics lecturers from the Biology Department, FMIPA and the Biology Education Study Program, FKIP Untan. The readability of the diagnostic test questions was also tested by 25 respondents who were not included in the core participants. The same steps were also taken for the student knowledge sources questionnaire. After being revised according to input from the two validators and the readability test results, the diagnostic test questions and the student knowledge sources questionnaire are ready to be used.

At the implementation stage, diagnostic test questions were distributed to students from three selected schools based on randomization results. The test questions are given

in the form of a Google form, but the filling is done directly and together at each school. The time for collecting student answer data is adjusted to the schedule provided by the teacher from each school. The length of time for completing the questions is the same for the three schools which is 45 minutes with a calculation of 90 seconds to answer each question and 7.5 minutes to open the link and fill in the respondent's identity.

At the data analysis stage, the results of students' answers to diagnostic test questions and genetic knowledge source questionnaires were calculated. Data analysis was carried out by calculating the percentage for each answer. Next, the discussion and conclusions of the results obtained are written.

Instrument

The research instruments used in this study were a questionnaire about sources of genetic knowledge and diagnostic tests about students' preconceptions in genetic material. The questionnaire regarding sources of students' genetic knowledge includes questions about sources of genetic knowledge obtained at the previous level of education (in secondary school), sources of scientific reading outside of school learning activities, and knowledge obtained from extracurricular activities. The following is example of questions in the genetic knowledge source questionnaire as follows:

1. □ Yes □ No Genetics material was taught in junior high school.
2. □ Yes □ No I have many/several reading books on the topic of genetics at home.

Note: questions are delivered in Indonesian language

The diagnostic test chosen is in the form of multiple-choice questions accompanied by a Certainty of Response Index (CRI) (Hassan et al., 1999) to measure the respondent's level of confidence in answering the questions. CRI has a scale that is displayed along with each answer. This method gives instructions to students to give a number on a scale of 0-5 for each question that has been answered by students, which is adjusted to the level of confidence of the students themselves (Table 1). These are some of the questions in the diagnostic test:

1. Genetic material is ….
a. DNA
b. RNA
c. DNA or RNA
d. DNA and/ or RNA
e. All correct

Your CRI value for the answer above is ____

2. 2. DNA (deoxyribose nucleic acid) is found inside …
a. Cytoplasm
b. Mitochondria
c. Nukleus
d. Chloroplast
e. Lysosom

Your CRI value for the answer above is ____

Note: questions are delivered in Indonesian language

The criterions for CRI are if the answer is correct with a high CRI it means you understand the concept, if the answer is correct with a low CRI it means you guessed the answer given, if the answer is wrong with a low CRI it means you don't understand the concept, and finally if the answer is wrong and the CRI is high it means you have a misconception. The following is a six-scale table (0-5) which is included with the level of certainty of the answer proposed by Hassan et al. (1999), as follows:

Table 1. The certainty level of students' answers according to the CRI scale by Hassan et al. (1999)

CRI Scale	Description
0	totally guessed answer
1	almost guess
2	not sure
3	sure
4	almost certain
5	certain

Data Analysis

The data on the results of the objective tests filled in by the students is determined by the category of the level of understanding of the students' concepts. This criterion is based on true or false answers and low or high CRI scores following Hassan, Bagayoko, & Kelley (1999) and Rahayu (2018) so that it can be seen the understanding of students who do not understand concepts, understand concepts, guess, and have misconceptions (Table 2).

Table 2. Categorization to distinguish students who do not know the concept, know the concept, guessing and misconception.

Response Criteria	CRI value	Understanding Category
Correct answer	The answer is correct, but low CRI (< 2.5) means don't know the concept *(lucky guess).*	Guessing (G)
Correct answer	Correct answer and high CRI (>2.5) mean mastering the concept well.	Understanding Concepts (UC)
Wrong answer	Wrong answer and low CRI (<2.5) mean that you don't know the concept.	Don't Understand the Concept (DUC)
Wrong answer	Wrong answer but high CRI (>2.5) means that there is a misconception.	Misconception (MC)

After the data is obtained from the combination of student answers and CRI scores, the data is calculated to find the percentage of students' confidence levels in answering questions. The formula used to calculate the category of student understanding is as follows:

$$P = \frac{f}{N} x\ 100\%$$

Description:

Q : Percentage figure for understanding category

F : Number of students in each category
N : Total number of students

Analysis of the questionnaire data for the source of genetic prior knowledge was carried out descriptively by calculating the percentage for each factor. Next, the largest to the smallest initial knowledge source factors are determined.

▪ RESULT AND DISSCUSSION

From the diagnostic test given to 90 students of class XI SMA in Pontianak City, a description of the student's answers was obtained as seen in Table 3. The average initial concept profile of class XI students who are in the category of understanding concepts is 29%, while those who do not understand concepts are 27%, guessing 12%, and misconceptions 32%. The biggest source of understanding students' initial concepts is the knowledge that comes from schoolteachers. If it is associated with the student's initial concept profile, the highest as shown in Table 7 is the concept of genetic material at 49%, the constituent components of DNA at 47%, types of genetic material at 43%, and the protein synthesis process by 42%. These four concepts are also found in the science material for third grade students at junior high school with Basic Competence 3.3, namely applying the concept of inheritance in the breeding and survival of living things. The indicators in this basic competency include an understanding of genetic material, the structure of DNA and chromosomes, and the inheritance of traits in living things. When viewed from the source of student knowledge obtained from teachers in schools, this highest initial concept can be related to the learning experiences of students at the previous level with teachers at school. According to Radiusman (2020), when students understand the concepts in a material, they will easily solve problems in learning. Concept understanding has a close relationship with problem-solving where the subject and knowledge hierarchy of a topic is a continuation of the previous topic so that students can understand new knowledge because they have information about previous knowledge (Brod, 2022).

Table 3. Diagnostic test question indicators

Material Concept	Indicator	Question Number	Student's Conception in Categories (%)*			
			UC	DUC	G	MC
Types of genetic material: DNA, RNA	Name the molecule of genetic material	1	43	12	6	39
Location of genetic material: DNA – nucleus, RNA – nucleus, cytoplasm	State the location of the DNA	2	49	19	10	22
The function of genetic material: store genetic information	Explain the function of genetic material	3	36	20	18	27
DNA Structure	State the characteristics of DNA	4	18	27	16	39

Components of DNA	Sequencing the components of DNA	5	47	16	10	28
Chromosomal structure	Labeling the structure of chromosomes	6	22	34	12	31
Components of Chromosomes	Name the type of chromosome	7	39	26	9	27
Types of chromosomes based on the location of the centromere	Name the types of chromosomes based on the location of the centromere	8	21	38	13	28
Chromosomal components: the number of autosomal and gonosome chromosomes in humans	Name the types of chromosomes based on the location of the centromere	9	33	27	7	33
Structure and Function of DNA: characteristics and properties of DNA	Categorize the characteristics and properties of DNA	10	18	24	22	36
Process of protein synthesis: DNA replication	Explaining the printout in the transcription process	11	37	20	17	27
Differences between DNA and RNA: shape, properties, nitrogenous bases, sugars, function, and location	Classify the difference between DNA and RNA	12	17	38	8	38
Chromosome Function	Explain the function of chromosomes	13	24	31	13	30
DNA Function	Explain the function of DNA	14	36	24	11	29
DNA Replication Function	Explain the nature of RNA during the transcription process	15	17	34	16	33
Paired Gene Structure	Name the structure of the paired gene	16	27	33	12	28
Chromosomal structure in cell division	Name the structure of the paired gene	17	17	27	13	43
RNA function	Name the types of RNA	18	32	30	11	27
Protein Synthesis Process	Mention the process of protein synthesis, including the stages of protein synthesis, the materials needed for protein synthesis and the results obtained after the protein synthesis process	19	19	24	10	47
		20	32	21	13	33
		21	26	27	16	32
		22	42	24	9	24

Order of Nitrogen Bases in the process of protein synthesis	Name the enzymes needed during the translation process, and be able to name the sequence of nitrogenous bases	23	27	37	10	26
		24	36	29	11	24
		25	12	42	4	41
			29	27	12	32

*Note: UC : understand concept, DUC = don't understand concept, G = guess, MC = misconception

The category of not understanding the highest concept is found in the concept of nitrogen base sequences in the protein synthesis process, which is 42%. If we look at the material in the previous level, this concept has not been explained even though the nitrogen base sequence is part of the genetic material. Understanding the nitrogen base sequence concept is most likely not understood by students considering the demands of student achievement at the previous level do not discuss the nitrogen base sequence but rather the inheritance of traits.

In the student's concept understanding profile in the guessing category, the highest percentage lies in the concept of the structure and function of DNA, which is 22%. Low student confidence also indicates students' guesses in answering questions. However, if we look at the material at the previous level, the material on the structure and function of DNA has been presented. According to Istiyani, Muchyidin, & Rahardjo (2018), students guess because they are not confident due to the lack of understanding of the concept, so students feel unsure of their correct answers.

Next, the highest percentage in the category of misconceptions lies in the concept of the protein synthesis process at 47%. The concept of the protein synthesis process is included in the material for the inheritance which has also been conveyed in science learning at the previous level. According to Yuliati (2018), misconceptions can occur due to several factors, namely the absence of students' prior knowledge regarding the concept, stages of cognitive development that are not in accordance with the concepts being studied, as well as students' lack of ability to capture and understand the concepts being studied and students' lack of interest in learning. concepts taught. Misconceptions of protein synthesis is one of common subjects found in learning genetics (Fisher, 1985). The obstacles of comprehending the domain-specific language of the terminologies (Pearson & Hughes, 1988), the function of genes (Gericke, Hagberg, & Jorde, 2013), the relationship between genes and proteins (Duncan & Reiser, 2007), and protein synthesis as a whole process (Gericke & Wahlberg, 2013) make the concept more poorly understood and investigated (Knippels, 2002).

Regarding prior knowledge, students know many things from their daily experiences even before the formal school level, and it is from this experience that students' initial knowledge is formed. However, the initial knowledge obtained by students can be right or wrong, which is caused by inaccurate student information sources and the experiences experienced by students are also different. The initial knowledge possessed by these students is very important because it can affect the acquisition of student knowledge at the next level of education.

The explanation of the student's initial concept profile described above is also reflected in the highest source of genetic knowledge recorded in the questionnaire.

Successively, the highest source of student knowledge was from schoolteachers (79%), followed by textbooks (64%), science books (63%), textbooks (62%), parents or family (60%), mass media (49%), social media (42%), friends (38%), films/videos (37%), tutors/courses (36%), handbooks in tutoring places (30%) and study groups (22%). If it is related to the student's initial concept understanding, then the knowledge that comes from the teacher at the previous level is the biggest factor affecting the students' understanding of the highest concept which in this study was recognized by 79% of respondents.

The next highest source of knowledge is textbooks. The books mentioned in the questionnaire include textbooks used in biology learning, science books, and other textbooks. The percentage of textbooks used in biology learning is 64%, science books 63% and other textbooks 62%. Sources of knowledge derived from this book are high because it can be assumed that students bring these books, both those related to lessons at school and those related to science, so that students gain knowledge from these books. According to Rostika (2016), textbooks are learning tools that aim to increase students' interest in learning activities. Procurement of textbooks lent to students can also help students repeat school learning at home. In addition, the material in the textbook is presented in easy-to-understand language to support student learning success. By reading textbooks, students become richer in information and easily understand the learning material provided by the teacher (Supriyo, 2015).

Furthermore, the source of knowledge from parents or family is 60%. It is assumed that most parents participate in helping their children learn at home. According to Qomariyah (2015), parents have the most important position in shaping the character of a child. The attention and guidance of parents at home will affect student learning readiness, both studying at home and school. The attention given by parents to children can motivate students to carry out their activities, including motivating them to learn. Parents who are less or do not pay attention to their children's education can cause children to be less successful in learning (Safitri & Nurhayati, 2018). Moreover, family influence also has a significant impact during career decisions (Kocak et al., 2021). In fact, responding to developments in the field of genomics and increasingly individualized medicine, getting used to discussions in the field of genetics in the family has become a demand to increase genetic literacy in society (Little, Koehly, & Gunter, 2022).

Meanwhile, the lowest source of knowledge in the study group by 22%. According to Magaji, Ade-Ojo, & Bijlhout (2022), specific extracurricular activities in certain fields of study have been proven to help students' learning development. The low percentage of source of knowledge in the study group because it is assumed that most respondents do not join any science study group at school. On the other hand, throughout a child's developmental period, there are emotional, physical, spiritual, and moral development needs that can be fulfilled and completed through extracurricular activities (Sadykova et al., 2018).

Overall, the percentage of students who do not understand concepts is much lower than those who understand. This means that the understanding of the initial concept of genetic materials of second-grade students in Pontianak City is still low so the teacher must handle the learning process optimally. The teaching method and approach for students who do not understand concepts, guesses, and misconceptions may be different so teachers must prepare careful lesson planning.

One way that teachers can do is to plan the best learning models and media to overcome the low understanding of students' concepts at school. Various studies have presented findings related to learning designs with the aim of improving learning outcomes in genetic material. Venville & Donovan (2008) use an analogy with models for abstract concepts in genetics, for example genes and DNA. Knippels, Waarlo & Boersma (2005) divided four learning and teaching strategies depending on the characteristics of the material to overcome the abstract and complex properties contained in genetic material. One of the four strategies is that dealt with the relationship between meiosis and inheritance which is made explicitly. This yo-yo learning and teaching strategy was previously developed by Knippels (2002). In connection with the findings in this research, students' initial concepts can be a basic reference for ascertaining concepts that will be difficult for students to understand. Mastery of various learning models and techniques will certainly give teachers the flexibility to apply them according to the characteristics of the genetic material that will be provided.

▪ CONCLUSION

The percentage of students who understand the genetic concept is lower than those who do not understand, guess, and have a misconception. Meanwhile, the highest source of student knowledge was from schoolteachers. This means that the understanding of the initial concept of the second-grade students at high school in Pontianak City is still low and the teachers play important roles in shaping the student's knowledge.

Due to these findings, teachers should be better at planning the learning process. An overview of students' initial concepts can be a guide for emphasizing concepts that will be difficult for students to understand and may require specific learning techniques and methods. Mastery of various techniques and learning models can really help teachers to apply the results of students' initial concept descriptions in previous classes.

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