ANALYSIS OF CK (CONTENT KNOWLEDGE) OF PRE-SERVICE BIOLOGY TEACHERS ON CONCEPT OF GENETICS AND ECOLOGY

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Abstract

Content Knowledge (CK) is an ability to reveal a particular object based on the characteristics possessed by the object. The purpose of this research was to analyze the ability of Content Knowledge (CK) of Pre-service Biology Teachers to be viewed based on concept comprehension test. The study used qualitative methods, measured by giving a test in the form of a description of the genetics and ecology, the questions were compiled based on Bloom's taxonomy Revision from C2-C4 level. The research show that; in general prospective teachers have low mastery on the concept of gene regulation, Mendel's Law, and protein synthesis, but they have a good concepts on comprehension of Genes, DNA, and chromosomes, mutations, DNA relations, RNA, polypeptides, transcription and translation in the function of the formation of the nature of living things, and the relationship between sexual reproduction and gene inheritance. For the concept of ecology, in general they have a low mastery on the concept of interaction between organisms, biomass, community of organisms and global changes. While they have a good mastery on concept of the food chain system and the flow of energy, and the population.

Keywords*: Content Knowledge (CK), Genetics, Ecology

INTRODUCTION

Genetics is one of concepts that has an invisible, inaccessible and composed character of complex structures. Genetics concept consist of knowledge about structure and process. In terms of structure, genetics involves many levels of biological organization from molecular, cellular to multicellular such as genes, proteins, cells, tissues, organs, etc. In terms of the genetics process, it is also composed of many complicated processes such as mitosis, meiosis, monohybrid and dihybrid crossing, and so on. The concept of genetics consists of various sub concepts that each have different characteristics, for example in learning sub concepts of genetic material and the principle of heredity it certainly needed different ways to make learning more meaningful. Today's genetics is one of the most important concepts to be learned and understood well by students. The application of genetics today has been very widespread starting in the field of health, reproduction. A good understanding of genetics will be directly proportional to the application of basic concepts in everyday life. Therefore, effective learning is needed in schools with attention to various aspects that support the achievement of students' understanding intact, for the best learning would require planning that takes into account various factors such as understanding the character of genetics concept which of course it is different from other concepts. If a teacher knows the characteristics of the genetic concept then a teacher can adapt the learning. Furthermore it is also necessary knowledge of difficulties and misconceptions that are generally owned by students so that learning can depart from the problems experienced by students. Learning that departs from the

difficulties and misconceptions experienced by students can be right on the target so that learning is more effective.

According to De Beer 2011 in Van Wyk (2013) the concept of DNA, meiosis, protein synthesis and heredity is a concept that is difficult to be understood by students. Students have a low understanding of this concept and they may experience misconceptions. In particular, students can not differentiate between the phases in meiosis and the different stages of protein synthesis. Another example of misconceptions that may occur in students, it is about the character of the gene. Students assume that one gene determines one character, one mutated gene always causes the disease, and the gene will always be expressed into phenotype. Content knowledges includes depth, breadth, accuracy of content knowledge, relationships within and between topics as well as the character of science, and examples of a topic (Borowski et al., 2011). In terms of genetic structure involves many levels of biological organization from molecular, cellular to multicellular such as genes, proteins, cells, tissues, organs, etc. Genetic processes are also composed of many complicated processes such as mitosis, meiosis, hybrid monohibrid crossing, etc. A good understanding of genetics will be directly proportional to the application of basic concepts in daily activities. According to Topcu and Pekmez (2009), one of the most difficult concepts by students is genetics concept. Students find it difficult to understand about structures (genes, gametes, alleles, etc.) and processes (cell division, crosses, etc.). of

structures (genes, gametes, alleles, etc.) and processes (cell division, crosses, etc.). Those will be elaborated in the following description:

a. Students have difficulty to differentiate mitosis and meiosis to associate it with the genetic inheritance process

b. Students have difficulty to visualize or imagine genetic structures based on their size in cells

c. Students have difficulty to understand the functions and relationships between the genetic structures (eg between alleles, DNA, chromosomes, and genes)

d. Students have difficulty to understand the influence of the environment on genetics because students often ignore the influence of the environment

e. Students have difficulty to understand the process of how genetic information is transferred from one generation to another

f. Students have difficulty to distinguish genes that are linked to autosomes or genosomes

g. Students have difficulty distinguish between dominant and recessive genes

h. Students have difficulty to understand the genotype and phenotype

In addition, the concept that is considered quite difficult in genetics is a deviation of mendel law. This concept is composed of several subconcepts to understand it required the ability of high-level thinking such as applications, analysis, and synthesis (Marshall, Pamela A. 2008).

1. Several studies have also been conducted to analyze misconceptions that occur in

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students related to the concept of genetics, following some misconceptions that exist in the concept of genetics: Genetic technology Students consider that all genetic engineering techniques involve the engineering of genetic structures. For example, cloning techniques to transfer somatic cells from one organ to another do not involve the engineering of genetic structures. Students assume that by genetic engineering, we can mix the genetic structure of animals and plants.

2. Pattern of genetic inheritance Students assume that if we are more like one parent (father or mother) it means we have more genetic inheritance from that parent. In the inheritance of the disease students often mix between autosomal diseases with the genosome so that all diseases can be reduced to the next generation.

3. Gene character Students consider that one gene determines one trait. One mutated gene always causes disease. The genes will always be expressed into phenotypes

4. Character of gene structure Students assume that bacteria and fungi have no DNA. Students consider that chemical compounds (pesticides, iodine, vitamins) can alter their genetic structure. The genetic structure of a cell is different from other cells because of the difference in function and its location

5. Genetic diseases often confuse students, for example mentioning that HIV and cancer are genetic diseases and can be inherited, whereas many diseases involving genetic material may not be inherited to their offspring. Students consider that genetic disease is completely incurable.

In addition to the concept of genetics, one of the most difficult biological material to understand is ecological material. In this concept students have difficulty in understanding concepts such as: chains and food webs, cycles of matter, and ecology of niches. One of the obstacles in ecology lessons is the uncertainty about the facts, concepts and terms that must be understood, even these conditions are seen in school books where the same term is used in different ways. Another difficulty encountered is teacher-centered learning, which should be student-centered learning so that students can develop an understanding of their own concepts through learning experiences. Ecological material is considered difficult because it has a complex concept and interrelated, one of the most important concepts is the ecosystem, there are 3 important processes in it, namely: photosynthesis, rotation of substances, and energy flow (Yorek et al, 2010). Over the last few decades, research on ecology teaching and learning has revealed that students have some ideas that are contrary to scientific knowledge although ecology is among the most important aspects of the biological curriculum. (Aubusson, 2002; Eilam, 2002; Griffiths & Grant, 1985, in Yorek et al (2010)).

Other studies which also revealed that there is a misconception about the concept of energy flow. These misconceptions formed from the ground level, and continue through the college level and this suggests the strong possibility that elementary and secondary teachers may

also have difficulty in understanding the same concept. A teacher not only defines the key to ecological concepts but needs to be given a learning experience that can improve students' understanding of concepts. Complex concepts can not be directly taught to students, teachers must have experience that allows them to create and build, much higher cognitive relationships (Puk & Stibbards, 2011).

The concept of genetics and ecology is a much different concept, both in terms of its content characteristics, the strategies used to teach, and the difficulties of each concept in teaching it are also different. So it required the ability of teachers in concocting a good learning planning and have good content for the realization of meaningful learning for students. Both of these content include content recommended by NSTA (2003), which contains:

> "*General concepts of genetics and heredity, molecular genetics and heredity and mechanisms of genetic modification*" and "*Life process in living systems including organization of matter and energy, ecological systems including the interrelationships and dependencies of organism with each other and their environments, population dynamics and the impact of population on its environment, applications of biology in environmental quality and in personal and community health, biochemical interactions of organism with their environments*",

At the second high school level this concept must be mastered by students. In the 2013 curriculum, competencies related to ecological concepts that must be mastered by students are able to describe the diversity of genes, species, ecosystems through observation activities, able to describe the biodiversity of Indonesia, and conservation efforts and the utilization of natural resources. While the competence related to the concept of genetics is that students are able to describe the concept of genes, DNA, and chromosomes to describe the relationship of genes (DNA) -RNA-polypeptide and protein synthesis in the function of the formation of living organisms, to describe the link between the process of division of mitosis and meiosis with inheritance properties, to understand the principle of heredity in the mechanism of inheritance of nature, and to describe mutation events and their implications in each other.

METHODS

This type of research is descriptive research, in line with what is described (McMillan and Schumacher, 2001). This method does not provide treatment, manipulation, or alteration to independent variables, but describes a condition as it is. The population in this research is biology students of sixth semester students and the sample is pre-service biology teachers who hired 9 courses of Biology Learning Planning (PPB) at Universitas Pendidikan Indonesia (UPI).

a. This study uses the concept master test instrument, in the form of 8 items of description. The issue was compiled based on the Bloom's cognitive sphere of revision from the C2-C4 level of measurement of mastery of the genetic concept. Prior to use, the concept master test questions are tested first. The steps of preparing the concept

mastering test are as follows: Creating a grid of questions that include the concept of genetics.

b. Compilenge questions and answer keys.

c. Conducting judgment of instruments to expert lecturers in the field of study and pedagogy experts. Judgment aims to know the validity of the problem, the suitability between learning indicators with problems and conformity with the key answers.

d. Conducting test of concept mastering test on other prospective teacher class students who contract the subject of PPB. Next checking the results of the test questions with a maximum score of 4 and a minimum score of 0.

e. Calculatinges test validity, item validity, reliability, difficulty and distinguishing features using ANATES Version 4.0.5 software

DNA, RNA, polypetide, transcription, and translation in the function of the formation of the nature of living things, and 7. The relationship between sexual reproduction and gene inheritance.

Table 1. Distribution of mastery scores on the concept of genetics

RESULT AND DISCUSSION

Knowledge of content (Content Knowledge) of pre-service biology teachers is measured by giving a test in the form of a description of the concept of genetics. Genetic tests are 7 items of description. Prior to use, a matter of concept mastering test has been tested in advance on other prospective teacher students of other classes who contract the subject of PPB. There are 7 concepts tested to prospective teachers related to genetics, namely: 1. Genes, DNA, and chromosomes, 2. Mutations, 3. Mendel's Law, 4. Gene regulation, 5. protein synthesis, 6.

No	Pre-service teachers	Questions							Total	Final score (%)
		Gens, DNA, and chromosome	Mutation	Mendel Law	Gen Regulation	Protein Synthesis	The relationship of DNA, RNA, polypeptide, transcription, and translation in the function of the formation of the nature of living things	The relationship between sexual reproduction and gene inheritance		
1.	RHD	4	4	4	0	4	4	3	23	82
2.	SRP	4	4	3	1	2	4	4	22	79
3.	ERN	3	4	2	2	3	4	3	21	75
4.	ADN	3	3	2	1	4	4	3	20	71
Avarage upper group									**22**	**77**
5.	SHL	4	4	3	1	3	0	3	18	64
6.	END	3	2	4	0	3	3	3	18	64
7.	KRT	3	4	3	0	1	4	2	17	61
8.	EIS	3	3	2	0	2	4	3	17	61
Avarage middle group									**18**	**63**
9.	DVY	3	3	2	0	2	3	3	16	57
10.	DTA	2	2	1	1	1	4	1	12	43
11.	YLI	2	2	1	1	1	4	1	12	43
12.	WND	2	1	1	0	1	3	1	9	32
Avarage lower group									**12**	**44**
Jumlah		36	36	28	7	27	41	30		
Rata-rata (%)		75	75	58	15	56	85	63		61

From Table 1, prospective students were grouped into three groups based on the order of scores from the total score of 61, ie: the upper group consisted of RHD, SRP, ERN, and ADN

teachers with an average of 77, middle group consisted of SHL, SHD , KRT and EIS with an average of 63, while the lower group consisted of DVY, DTA, YLI, and WND teacher candidates with an average of 44. The distribution of conceptual mastery scores indicates the mastery of each teacher's concept on each concept in genetics, it was found that the prospective teachers already understood the concept of the relationship of genes (DNA), RNA, polypeptide, transcription and translation in the function of the formation of the nature of living things seen from the score of each prospective teacher, except the SHL teacher candidate who got a score of 0. In addition, all prospective teachers already understand the concept of the relationship of genes, DNA, and chromosomes and mutations seen from scores obtained above the average of 75, except prospective teachers who won WND score 1. For the concept of gene regulation, in general the prospective teachers have a low mastery seen from the average score obtained is 15, based on the results of interviews with prospective teachers this is because they have not obtained a briefing related to the concept of gene regulation. Prospective RHD teachers generally master all existing genetic sub-concepts, except for the gene regulatory sub-consepts of score 0. The WND teacher candidates do not understand the sub-concepts of genes, DNA, and chromosomes and mutations. It was compared with other prospective teachers who already understand the subconsep well. Prospective teachers of DTA, YLI, and WND have a low mastery of the sub-consept relationship between sexual reproduction with genetic inheritance and Mendel's legal sub-consepts, prospective teachers get a score of 1. In addition, protein synthesis is also a subconsion that is difficult to understand. It can be seen from the score obtained by KRT, DTA, YLI, and WND candidates who got a score of 1. According to De Beer 2011 in Van Wyk (2013) the concept of DNA, meiosis, protein synthesis and genetics are difficult concept for students. Students have a low understanding of this concept and they may experience misconceptions. In addition, the concept that is considered quite difficult in genetics is a deviation of mendel law. This concept is composed of several sub-concepts and to understand it required the ability of high-level thinking such as applications, analysis, and synthesis (Marshall, Pamela A. 2008).

Mastering the content of prospective teachers on each concept in ecology can be seen in the distribution of scores in Table 2. The maximum score is 4 and the minimum score is 0.

Table 2. Distribution of ecological concept master scores

No	Pre-service teachers	Questions								Total	Final score (%)
		Food chain systems and energy flow	Interaction between organism	Biomass	Population	Community of the organism		Global Change			
1.	RHD	2	3	4	3	3	4	4	3	26	81
2.	DVY	4	4	3	3	3	2	1	3	23	72
3.	ADN	4	3	3	3	2	3	2	3	23	72
4.	SRP	4	1	3	3	0	4	4	3	22	69
Average upper group										**24**	**74**
5.	SHL	3	4	3	3	2	2	2	2	21	66
6.	ERN	4	1	2	2	3	3	3	1	19	60
7.	EIS	3	1	2	3	2	2	2	4	19	60
8.	KRT	2	1	1	3	2	2	2	3	16	50
Average middle group										**19**	**59**
9.	DTA	2	1	2	3	2	1	2	2	15	47
10.	END	2	1	1	3	2	2	2	2	15	47
11.	YLI	2	3	3	1	2	1	2	1	15	47
12.	WND	2	1	1	3	2	2	2	1	14	44
Average low group										**15**	**46**
Jumlah		34	24	28	33	25	28	28	28		
Rata-rata (%)		71	50	58	69	52	58	58	58		60

Based on the distribution of the score of mastery of the concept of ecology of the prospective teacher students are also grouped into three groups based on the order of values of the total score of 60, namely: the upper group consists of RHD, DV, ADN, and SRP teachers with an average grade of 74, teachers of SHL, ERN, EIS and KRT with an average score of 59, while the lower group consists of DTA,

END, YLI, and WND candidate teachers with an average score of 46. The distribution of concepts mastery scores indicates the mastery of the concept of each candidate teachers in each concept in ecology, generally the prospective teacher understands the subconscope of the food chain system seen from the average score obtained at 71. However, RHD, END, KRT, YLI, and WND candidates do not understand the sub-concept of the food chain system and the flow of energy is seen from the score obtained is 2. According to Puk & Stibbards, (2011) that there is misconception about the concept of energy flow, misconception is formed from the level basic, and continuing up to college level and this demonstrates the strong possibility that elementary and secondary school teachers may also have difficulty in understanding the same concept. One of the obstacles in ecology lessons is the uncertainty about existing facts, concepts and terms that must be understood, even such conditions are seen in school books where the same term is used in different ways (Sander et al, 2006 in Yorek et al, 2010). Ecological material is considered as difficult subject because it has a complex concept and interrelated, one of the most important concepts is the ecosystem, there are 3 important processes in it, namely: photosynthesis, rotation of substances, and energy flow (Yorek et al, 2010). For the sub-concept of interaction between organisms almost all prospective teachers have low mastery, ie prospective teachers SRP, ERN, EIS, KRT, DTA, END, and WND. Prospective teachers get a score of 1 out of maximum score 4. KRT, END, and

WND teachers are less aware of the biomass subconsepts, prospective teachers get a score of 1. YLI teacher candidates have a low mastery of the population subconsepts. SRP teacher candidates get a score of 0 on the community subconscope of the organism, meaning that prospective teachers also have low mastery. In addition, prospective teachers of DTA and YLI obtained a score of 1 related to the subconsep. Prospective teachers of DVY, ERN, YLI, and WND are also poorly understood about the sub-concept of global change, prospective teachers get a score of 1.

Basically, content mastery is the ability of a person to re-express a particular object based on the characteristics possessed by the object. Concepts, principles and structures of knowledge and problem solving are important learning outcomes in the cognitive domain. Content knowledge (Knowledge Knowledge) is a very important knowledge possessed by a teacher, no doubt that someone who wants to become a professional teacher must have this knowledge well. One aspect of the teacher who has the good qualities of the No Child Left Behind Act in Lenhart (2006) is to have the breadth and depth of content. The US Department of Education (2004) states that teachers must prove that they know about the content they are teaching and in accordance with the areas they teach. Ahtee & Johnston, 2006 in Lenhart (2010) states that low in the subject of knowledge can cause a teacher difficulty in teaching. In addition, on the subject matter, (Harlen & Holroyd 1997 in Purwianingsih 2011) a strong content

knowledge of a teacher will have a positive impact on decision-making related to changing teaching strategies to create better learning opportunities. Rich (2008) in Ozden (2008) shows that is a significant relationship between Content Knowledge and Pedagogical Content Knowledge of science teacher candidates. Similarly, many researchers such as Halim and Meerah (2002), Van Driel, De Jong and Verloop (2002) concluded that content knowledge influences Pedagogical Content Knowledge (PCK) teachers. In addition, results of research conducted by Ozden (2008) emphasize that content knowledge has a positive effect on PCK and effective teaching.

CONCLUSION

In general, prospective teachers have low mastery of the concept of gene regulation, Mendel's Law, and protein synthesis, but they have a good mastery of the concepts of Genes, DNA, and chromosomes, mutations, DNA relations, RNA, polypeptides, transcription and translation in the function of the formation of the nature of living things, and the relationship between sexual reproduction and gene inheritance. For the concept of ecology, in general the prospective teachers have a low mastery of the concept of interaction between organisms, biomass, community of organisms and global changes. While they have a good mastery on the concept of the food chain system and the flow of energy, and the population.

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