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The Distribution of Patterns and Types of Questions in Genetic Learning Implementing Reading-Questioning-Answering Learning Model

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ABSTRACT

It is important to identify the characteristics of questions in learning activities so teachers understand the material mastery level of students. The study aimed at documenting the patterns and types of questions in genetic lecture using RQA (Reading, Questioning, Answering) learning. The data were collected by documenting all the questions during the learning process, and the sentence structures were analyzed referring to the guide of Krathwohl as the revision form of the Bloom guide. The findings of the study showed that the patterns of questions were not always similar to the questioning skill theory due to the linguistic structure and the understanding in communication during the learning interaction. The most types of questions occurred were *understand* as much as 40.3% related to cognitive dimension, *conceptual* as much as 41.1% related to knowledge dimension, and *classify* as much as 23.4% related to the cross section between cognitive and knowledge dimension. These results are important for the evaluation based of the learning achievements.

Keywords: cognitive dimension, genetic learning, knowledge dimension, question distribution, RQA learning model

INTRODUCTION

In modern society, education innovations are needed in order to keep up with the dynamics of the era development, including the process and the practice of education (Zhakhina, 2016). Likewise, learning activities should also be oriented to the improvement of learning outcomes. The main target of learning is that students can understand the concept well so it might contribute to change and improvement of knowledge as well as behavior based on the concept learnt. Teachers implement various models, approaches, strategies, methods, techniques, tactics, and learning media to achieve the learning goal. These efforts are used to facilitate teachers to wrap the learning materials, facilitate the learning interaction, improve students' participation and comprehension, as well as to achieve the learning objectives easily.

There are many learning models, one of which is RQA (Reading, Questioning, and Answering) learning model implemented by its pioneer in Genetics class of State University of Malang, Indonesia. Since 30 years ago, the genetic class in State University of Malang has implemented RQA learning model. At the first step, the students are required to read learning materials based on the topic reference from various sources, either based on the lecturer's recommendation or other supported sources such as journals, research reports, and text books. Based on the reading results, the students might generate questions as the reading activities

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reflection. The type of the questions depends on the depth and width of the students' understanding to see problems from different angles. The next step is that students create the answers by themselves based on the questions. The quality of the answers depends on the accuracy of the answers and the depth of the discussions based on various supporting ideas (Corebima, 2014).

Bahri (2010) stated that RQA learning might improve student metacognition as much as 22.77%, and the metacognition skill of the low academic students increased 57.4% higher than those of the high academic ability. Other RQA studies also verify that this learning model is able to improve student learning outcomes, metacognitive skills, competences, and shorten the distance between student academic ability (Hasanuddin, 2013; Khairil, 2009; Sumampouw, 2011). This finding is in line with Corebima (2014) statement related to the descriptive analysis of mean scores of students' metacognition skill in each RQA assignment showing an improvement of the overall scores; furthermore, the students' metacognition skills also improve from the first to the last assignments. The data analysis results showed that the initial metacognition skills were extremely different from the final metacognition skills. Therefore, it was concluded that the metacognition skills of the students improve significantly from the initial measurement to the final measurement of RQA learning model.

Based on the studies mentioned above, to date there is no study yet related to question characteristics of the students conducted, especially during a discussion phase. In this case, students raise several questions originated from the previous lesson such as from resume assignment through reading activity, organize a question list through either questioning activity or spontaneous performance during a discussion. Omar et al. (2012) state that question is an important feature since it is an element closely related to evaluation. The quantity of the questions presented plays an important role in encouraging students to face tests of each cognitive level in each semester. The effective question types should be a guide to help the students' desire to achieve better learning outcomes. Futhermore, the low level questions involving C1 (remembering), C2 (understanding), C3 (applying) categories and the high level questions involving C4 (analyzing), C5 (evaluating), C6 (creating) categories should be in balance. These categories are based on the revised Bloom taxonomy (Bloom, et al. 1956) conducted by Krathwohl (2002), where synthesis (C5) is replaced by evaluating and evaluation (C6) is replaced by creating. Munzenmaier and Rubin (2013) argued that students needed also to utilize their low level of knowledge as well as of skills in answering a high level question. Thus, the questions should be documented in the sense of the depth and width, which depend heavily on the student ability in enriching reading and finding some specific things to be asked. It is also necessary to conduct a study related to patterns and types of questions of students in learning activities employing the RQA learning model. The study result will be very useful to improve the implementation of the RQA learning model in the future. This study result is useful too to develop the skills of questioning in the classroom, guiding the students to develop the overall learning skills.

RESEARCH METHOD

This research was conducted in the Biology Department of State University of Malang using qualitative and quantitative approaches in pre-experimental design because there was no control class. The research subjects were 25 students (24 females and 1 male) taking Genetics course in the odd semester of 2014/2015 academic year. This research used a purposive sampling technique, in which one class was determined out of the six classes. The selected class was that having best learning interaction as well as best learning dynamics compared to those of the others.

This research aimed at analyzing the patterns and the types of questions that emerged in the interaction of the learning activities in the classroom. The data were collected using classroom observation by documenting the questions that the students raised during the learning process. The classification of the question types was analyzed based on Krathwohl (2002) as the revision form of Bloom's Taxonomy (Bloom, et al. 1956), dividing the question types into two dimensions, namely cognitive dimension (remember Q1, understand Q2, apply Q3, analyze Q4, evaluate Q5 and create Q6) and knowledge dimension (factual QF, conceptual QC, procedural QP, and metacognitive QM). For the cognitive questions only, the patterns of the questions were descriptively analyzed using Morgan and Saxton (2006) that emphasized on *clue* words or phrases for determining the types of questions. The percentage of all the data of the question were then determined based on their types.

Table 1. The distribution of cognitive dimension question

Code	Cognitive Dimension	%
Q_1	Remember	33.1
Q_2	Understand	40.3
Q_3	Apply	4.8
Q_4	Analyze	16.1
Q_5	Evaluate	5.6
Q_6	Create	0

RESULTS AND DISCUSSION

The Question Type Based on Cognitive Dimension

In regard to revised Bloom Taxonomy, there are five types of questions (we call further as Q_1, Q_2, Q_3, Q_4, Q_5,**and** Q_6**),** such as question based on *remember* **(**Q_1**),** *understand* **(**Q_2**),** *apply* **(**Q_3**),** *analyze* **(**Q_4**),** *evaluate* ***(***Q_5***)*** and *create* **(**Q_6**).** It was found that the Q_2 questions had the most portion as much as 40.3%, followed by Q_1**,** Q_4**,** Q_3**,** and Q_5 questions, while Q_6 questions do not appear (**Table 1**).

The Q_2 questions appeared thoroughly in almost all learning meetings, so its frequency is higher compared to others. In the beginning of the learning meetings of the semester (meeting 1 to meeting 4), the Q_2 question overshadows other type of questions since the students need a comprehensive understanding of a course as the entry point to be able to view the overall concept map. This frequency increases in the middle of the learning meetings of the semester (meeting 5 to meeting 8) since the students are more confident in raising questions. In addition the students get the basic knowledge from the preceding learning meetings, which triggers their need in obtaining further explanation. The frequency decreases in the end of the learning meetings of the semester (meeting 9 to meeting 12) since the students have already known a lot, and the discussion materials tend to lead to technical case.

It is not significantly different from the Q_2 questions, Q_1 questions also appeared thoroughly in every learning meeting, yet in a little lower frequency, that was 33.1%. Related to Q_1 questions, there is no extreme fluctuation in each learning meeting about four question types. The decreasing number in the end of the learning meetings of the semester is caused by the fact that the students need to analyze the concept explanation which develops during the teaching and learning interaction. Moreover, the topics discussed are mostly related to technical procedure and practice results. The high frequency of the Q_1 questions is found in the discussion of protein synthesis, that is the expression of genetic material related to prokaryotic and eukaryotic translation. The similar phenomen is also found in relation to Q_2 questions, in which the protein synthesis discussion brings numerous questions. It indicates that although the explanation of protein synthesis concept in text book is quite comprehensive, yet it needs clearer understanding since the resources are written in foreign languages. The students also need more clarifications about poly-interpretable concepts so that they can get complete explanation of a particular concept.

The Q_4 questions were found in the beginning of the learning meetings of the semester together with the two previous types. The frequency of this type of question decreases once and then increases again in the last learning meetings of the semester, that is 16.1%. The fluctuation is caused by the fact that in the beginning of the learning meetings there was a discussion about Deoxyribonucleic Acid (DNA) as the central topic of this course. The understanding of the characteristics and behavior of DNA is the key point to comprehend the next learning concept. Therefore, the students try hard to analyze it well to examine the roles and the benefit of DNA in the context of genetic in the subsequent chapters.

The Q_5 questions were found in the middle to the last learning meeting of the semester, that was 5.6%, as the continuation of the in depth analysis in the beginning of the learning. It indicates that the students are able to see a certain concept be evaluated by using the preceding basic concepts. This ability is obtained after the students can analyze a certain concept and then compare it to other related concepts and evaluate it to generate a new idea from other perspectives.

The Q_3 questions had the least frequency, as much as 4.8%, found in the last learning topic, related to the topic of experimental project. The students often raise Q_3 questions which are related to the project procedures and the reasons related to the application of a certain project step. The discussion topics in the last learning meetings of the semester are mostly about the experimental project report during one semester written by the students.

The **Q_6** questions did not appear on all learning processes of genetics topics, because students may not dare to put forward the idea to create a synthesis of a new concept based on concepts that already exist. It requires internalizing time of genetic concept understood in depth and extent.

The Stages of Bloom Taxonomy of the Questions based on Cognitive Dimension

The pattern of student's questions is dynamic in nature. In **Q_1** questions, a question word "what" was the mostly used word. Morgan and Saxton (2006) stated that there were some clues that could be used to determine the **Q_1** questions level, namely what, who, why, when, where, and how. The clue word *what* refers to the questioner's desire to get an explanation or confirmation of a particular concept. Based on the observation conducted in the classroom, it was revealed that not all of the clue words were used as the basis of a **Q_1** questions, since the terms *how much* and *please elaborate* were sometimes used in the beginning of the questions. On the other hands, the interaction during the intensive discussion did not facilitate the questioners to create questions in proper grammar. It can be seen from the place of question word found in the middle or in the end of the sentence. Both the one giving question and the one answering the question used colloquial words and omitted the grammatical forms. Therefore, they sometimes eliminated the question words and said the point of the question without using the clues as suggested by Morgan and Saxton (2006), such as asking an explanation of a particular concept beginning with the word *please* in *Please re-explain* or the word *could* in *Could you tell me*. The distribution of these question patterns was invariable, in the sense that the same question pattern was always used in order to ask some abstract concepts in each meeting, or the questions raised did not agree with the questioner's mean. The questions mostly led to the basic concept, definitions, postulate, meanings, similarities, differences, purpose, or function by asking further explanations of a particular concept.

The same phenomena happened in **Q_2** questions. Pohl (2000) said that **Q_2** questions were mostly begun with some sentences, such as: *what does it mean?, which one is the fact?, is it the same with …?, what will happen if …?, what kind of expectation may we get from …?, what will be said by them about …?, what might be a …?, what might be possible in …?, is it valid?, which statement support …?, what delimitation did you add?, what will happen next?, can you explain …?, can you describe …?, does everybody think the way we think?,* and *explain why?*. In the observation conducted, there was no an exact word that could be used as a clue or standard, even the words used by the students were 100% different from the clues given by Pohl. It was caused by the desire to ask further explanation about an unknown fact. A questioner might use free sentences to organize questions wanted. For example a sentence *is it similar to …?* as stated by Pohl, became *what is the difference between …?, is not that aspect slower than …?, how to differ between …?, will those two things give the same impact to …?, or is not it the blocking factor, not the supporting one?*. The meaning of various questions found in the discussion activity is not significantly different from each other. Hence, Morgan and Saxton (2006) argued that the **Q_2** questions were mostly appeared in a question of self word, like giving examples, asking definition, abbreviating postulate, reading and presenting graphs and tables, or asking outlines. The distribution of the **Q_2** questions agrees with a normal curve graph, where in the beginning of learning meeting of the semester, there are few questions raised, just like in the end of learning meeting of the semester; however, there are more questions raised in the middle of learning meeting of the semester. Even though it might be similar to a normal curve graph, there are more questions of this type compared to other types of question. The patterns of questions leading to an act of asking further explanation are related to mechanism, stages, process, phases, causes and effects, strengths and weaknesses, advantages and disadvantages, series and sequences, calculation and prediction, or successes and failures and alike which indeed need further comprehension. Questioners most frequently ask for an explanation of a certain phenomenon deeply and comprehensively.

In the **Q_3** questions, the samples of the clues (Dalton & Smith, 1986, p. 1) are: *Do you know another example of …?, is it possible for … to …?, can you classify the characteristics like …, what factors will you change if …?, can you implement methods employed in your own experience?, what question will you ask …?, from the information given, can you develop a set of instruction related to …?, and is this information useful if you have …?*. Based on the observation results, these **Q_3** questions are not identical to the questions mentioned before, yet they have the same meaning, that is asking the implementation of a particular concept in a certain problem. For example, the question *what factor will be changed …,* was stated in different format as *how does the environment influence if …*. The **Q_3** questions are often used related to the process of practice, or the result of applying a theory of knowledge. The distribution of this question pattern is in contrast to the distribution of the **Q_2** question pattern, where the normal curve is upside down from the beginning to the last learning

meeting of the semester. In other words, most questions are raised in the beginning and in the end of the learning meetings of the semester. Indeed, based on material distribution**,** the last learning meetings are used mostly to discuss more practice results where the students usually apply the concept learnt since the beginning of the meetings. This type of question is the least type used compared to other types.

Different from the previous question pattern, the $\mathbf{Q_4}$ question pattern according to Morgan and Saxton (2006) is based on the questioners' opinion, in the sense that this type of question forecast the effect of treatment, estimate a cause, a reason of process, and evaluate the contradictory concept between the concept obtained from the learning activities and the questioners' own concept, so the answers might be in descriptive-elaborative form. The example of the question is *can a mitochondria lives by itself outside its main cell since it has DNA?*. To date, we do not find yet a mitochondria organelle lives away from a cell organization, yet the questioner might think from a perspective that there is DNA inside the organelle and also refers to Lynn Margulis' theory stating that the origin of a mitochondria organelle evolved from another cell that has a symbiosis with other organelles to form a modern cell organization. Out of the whole questions, there are some questions that are not raised from the questioners' stances; instead, they use the existing opinion then ask for further conclusion. For instance, *related to the fact that the element P might cause a sterile hybrid if male P x female M, yet it might be normal if male M x female P, what factors cause the element P be a sterilizing factor when it contained in male organism?*. The $\mathbf{Q_4}$ question pattern is almost the same and monotonous in each learning meeting, but it appears a little more compared to $\mathbf{Q_2}$ question pattern. It is a proper thing since questioners tend to ask about concept understanding deeper than the known concept, by confronting other similar concepts, or simply by comparing other phenomena to the questioned concepts. In other words, the raised questions are focussed at a particular concept by considering a particular phenomenon from a different perspective. The $\mathbf{Q_2}$ question pattern is deep in nature, but the $\mathbf{Q_4}$ question pattern is wide in nature.

Another question pattern is called $\mathbf{Q_5}$ question pattern which contains critics, supports, conclusions, and opinions (Morgan & Saxton, 2006). Based on the observation, the data obtained shows that all questions raised have the same pattern with the proposed patterns. Yet, the questions were started with clarification sentence or concept statement first. For example, *viruses having reverse transcriptase enzyme are more ferocious, such as HIV. Is it true?*. This kind of question is often raised as a longer question as well as question inform of a description. Firstly, questioner deliberately gives critique, protest or other opinion against the concept presented, then the questioner proposes the evaluating questions related to the concepts discussed. The distribution of this kind of pattern piles up in the middle of the semester meetings, and no question appears in the beginning and the last semester meetings. It is assumed that the students' critical ability appears in the middle of semester meeting in order to judge the learning concept learnt, and by the time they can understand the whole concept, so this question type will disappear in the end of learning meeting of the semester.

It is interesting to be informed that there is no $\mathbf{Q_6}$ question pattern raised during the learning meetings. This question pattern emphasizes the combination of several concept elements to form a new concept which is coherent or to form an original concept (Krathwohl, 2002). The absence of the highest level questions may be caused by the fact that the students were just recognized genetic concepts properly, so they were incapable yet of synthetizing their understanding comprehensively to arouse a new idea. It might appear in the advanced genetics courses.

The Question Type Based on Knowledge Dimension

The composition of the question distribution varies (**Table 2**), based on the knowledge dimension perspective namely ***Factual, Conceptual, Procedural,*** and ***Metacognitive*** type (**Table 2**). We call further those question as $\mathbf{Q_F}$, $\mathbf{Q_C}$, $\mathbf{Q_P}$ and $\mathbf{Q_M}$ respectively.

Based on **Table 2**, it can be seen that the $\mathbf{Q_C}$ questions dominate the learning interaction as much as 41.1%. This type of question expresses categories, classifications, schemes, models, theories, and concept interrelations. Two learning topics that often bring up $\mathbf{Q_C}$ questions are the topic of Meselson-Stahl experiment and Mutation. Both topics need a deep understanding of basic theory since it is related to the understanding of gene expression and the possible changing of gene structure.

Table 2. The distribution of knowledge dimension of question

Code	Knowledge Dimension	%
$\mathbf{Q_F}$	Factual	18.5
$\mathbf{Q_C}$	Conceptual	41.1
$\mathbf{Q_P}$	Procedural	12.1
$\mathbf{Q_M}$	Metacognitive	28.2

Table 3. The distribution percentage of cognitive & knowledge dimension

Code	$\mathbf{Q_F}$	$\mathbf{Q_C}$	$\mathbf{Q_P}$	$\mathbf{Q_M}$
$\mathbf{Q_1}$	16.1 List	11.3 Recognize	4.8 Recall	0.8 Identify
$\mathbf{Q_2}$	2.4 Summarize	23.4 Classify	7.3 Clarify	7.3 Predict
$\mathbf{Q_3}$	0.0 Respond	2.4 Provide	0.0 Carry Out	2.4 Use
$\mathbf{Q_4}$	0.0 Select	2.4 Differentate	0.0 Integrate	13.7 Deconstruct
$\mathbf{Q_5}$	0.0 Check	1.6 Determine	0.0 Judge	4.0 Reflect
$\mathbf{Q_6}$	0.0 Generate	0.0 Assemble	0.0 Design	0.0 Create

The frequency of the $\mathbf{Q_M}$ questions is in the second place (28.2%). This question type usually happens in transcription topic as well as in project report presentation. This question type depends on the students' cognition that generally appears from the students' control of their own cognition in learning in order to solve problems, find meaning of a text, analyze what is heard, elaborate or reorganize topic given. The transcription topic has a high difficulty level, and it needs a comprehensive understanding, so there are many extended questions needed to achieve the understanding desired during the learning interaction. In terms of the project report presented, it enables students to raise several deep questions to understand meaning and purpose of the project itself.

The third place in terms of the number of questions is placed by the $\mathbf{Q_F}$ questions (18.5%). It appears thoroughly to all learning topics. This type of question mostly confirms basic terms, basic concept elements, basic knowledges, and terminologies and unclear definitions or basic formulas as the key parameter in genetics discussion. An understanding of these basic matters extremely supports and helps students in conducting analysis and understanding of the advanced problems.

The lowest frequency of the questions is the $\mathbf{Q_P}$ questions as much as 12.1%. These questions are limited to concepts related to steps of a stage, how to do things, skills of conducting of a certain procedure related to techniques, methods, and ways and solutions but not results. Since the scope of Q_p question is very limited, not all topics can bring up this type of question. It is different from the other three types that might appear in every topic. The $\mathbf{Q_P}$ questions do not appear especially in the topic of replication and genetic code.

The Question Type Distribution of the Cross-Section between Cognitive and Knowledge Dimension

Anderson et al. (2001) compilated the atribute of learning process as part of the interaction between cognitive processes and type of knowlegde consisting of *List, Recognize, Recall, Identify, Summarize, Classify, Clarify, Predict, Respond, Provide, Carry Out, Use, Select, Differensiate, Integrate, Deconstruct, Check, Determine, Judge, Reflect, Generate, Assemble, Design* and *Create*. When a cross-section is done between the cognitive dimension and the knowledge dimension, we might obtain data as presented in **Table 3**. The determination of each attribute is arranged through three phases, which are the identification of the type of questions based on the cognitive dimension, the identification of question type based on the dimensions of knowledge, and conducting the cross-section and rechecking for each attribute that has been determined.

Based on the data presented at the **Table 3**, ***classify*** dimension mostly appeared among other dimensions. It shows that the questions developed involve identification processes in order to detect the characteristics or patterns that might be suitable to valid samples, valid concepts, as well as valid principles. In the Genetics course I, the students were required to comprehend well the basic genetic theory because concept

misunderstandings might contribute to misunderstandings of the Genetics course II and the final assignment. Therefore, it is very important for the students to quarry the concepts deeply in order to obtain a complete understanding of the Genetic I material. According to Long (2008), out of 500 essays chosen randomly to be analyzed in a Genetic misconception study, there are 278 essays (55.6%) having one definitive genetic misunderstanding and 101 essays (20.2%) having two or more misunderstandings. Roini (2013) reported that the average percentage of genetic concept possessed by biology teachers (in Ternate, Indonesia) was only 29.8% as well as by students was only 21.2%. This finding is in line with Hariyadi (2015) stating that none of the respondents said that they understood the entire course material of genetics. Hence, it is normal when the learning interaction in the genetic course I emphasizes the students basic understanding to avoid the misconception.

The interesting information of this data is the presence of metacognition dimension questions in every level of cognitive dimension. The reading, questioning, and self-answering activities before the RQA learning ignite an interaction between the concept 'read' and the concept 'believed', so it produces the new perspective as the results of such interactions. This is supported by Livingston (1997) stating that metacognition is thinking about thinking, so the acculturation of students new knowledge acquired during the RQA phase with prior knowledge that has been believed by the students has produced an interactive process thought. Thus it is a logical fact that this phenomenon appears at all topics because RQA learning is implemented at all learning meetings. It is in line with Corebima (2014) statement that RQA learning model is able to activate students' metacognition skill. It is proven by a study showing an improvement of the mean score in all aspects. It is also proven that students' metacognition skill improves from the first to the last assignments.

The $\mathbf{Q_F}$ question column rarely appears during the learning interaction, so does the $\mathbf{Q_P}$ question column. It is caused by the fact that the students have already known the definitions, terminologies or terms learnt in the Basic Biology course. The $\mathbf{Q_P}$ questions appear only in relation to techniques, methods, or stages of genetic practice works. It shows that related to $\mathbf{Q_F}$ questions the RQA learning model facilitates the students to comprehend the factual concept priorily in the reading stage, continued in self-questioning and self-answering stages.

Based on all the discussion presented before, it seems very clear that the guide of question type will be very useful for the teacher to identify the characteristics of questions provided by the students during learning process. It is recommended that the teachers have to pay great attention on this case in order to empower students' thinking ability, especially related to metacognitive skills, creative thinking skills, as well as critical thinking skills.

CONCLUSION

Based on the results of this research, it can be concluded that

- In relation to the cognitive dimension, the frequency of Q2 question was the highest one (40.3 %), while the Q6 questions did not appear in all of the learning process.
- In relation to the knowledge dimension, the frequency of QC questions was the highest one (41.1 %).
- In relation to the cross-section between Cognitive and Knowledge Dimension, the frequency of Classify questions was the highest one (23.4 %), whereas the QM and QC questions appeared in every level of cognitive dimension
- There was not any similarity of the question patterns appearing during the learning process using RQA model based on the clue words or phrases proposed by Morgan & Saxton (2006) as well as by other researchers.
- Thus, the patterns and the types of the questions of Genetics students tended to develop from the process of identifying the characteristics of the problems, in which the forms of the sentences were affected by the forms of the daily communication which based on sociolinguistics.
- The guide for identifying the characteristics of questions is very important for the teachers to identify all the question types provided by the students during learning process.

Disclosure statement

No potential conflict of interest was reported by the authors.

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