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Teacher Representations of Pedagogical Content Knowledge (PCK) in Biology Classroom

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Abstract. This is qualitative-quantitative research, where the main concern is to investigate pedagogical content knowledge representation of Biology Teachers and determine the effect and/or subsequent relationships with the student conceptual understanding. The study focuses on six biology teachers and a total of 222 students in their respective classes. The study utilizes classroom discourses analysis, interpretative case study method, bracketing method, and concept analysis for the qualitative part; the quantitative part uses a non-parametric statistical tool, Kendall's Tau Coefficient test on the relationship of Teacher's representation and students' conceptual understanding, and paired t-test for differences of pre- and post-instruction of concepts. The data collection entailed seven (7) months immersion: one month for preliminary phase for the researcher to gain teachers' and students' confidence and the succeeding six (6) months for the main observation and data collection for the research. The study reveals some patterns of teachers' activities inside a biology classroom, particularly in planning the lesson, motivation, assessing students, teachers' schema in representing content knowledge (Declarative and Procedural) inside the biology classroom. The effects and/or relationships of teachers' representation to students' conceptual understanding indicated that teachers' representation of content knowledge does affect the individual students' conceptual understanding by increasing complexity of their knowledge structure as well as spread of scores in the class.

Keywords: Teachers' representation, Pedagogical Content Knowledge, Philippine Setting

INTRODUCTION

The instructional ability of teachers inside the classroom plays a significant role in the teaching process. Evidence, which indicates the teachers' representation of content knowledge has a positive influence on classroom instructions, is available (Thorley and Stofflet, 1996). However, it is common knowledge in the academy that there are teachers who are equipped with content knowledge but are unable to translate their ideas into representations that can be understood by students. The translation of science into representations understandable in students distinguishes a science teacher from a scientist. Wineburg and Wilson (1991) stated that:

> *…their aim is not to create new knowledge in the discipline but to create understanding in the minds of the learners. Unlike the historian, who only has to face inward toward the discipline, The teacher of history must face inward and onward, being atone deeply familiar with the content of the discipline while never forgetting that the goal of this understanding while never…. forgetting that the goal of this understanding is to foster it in others…. it is precisely in the meeting of subject matter and pedagogy... that we see the expertise of…teachers most clearly (pp. 335-336)*

If this claim is resolved. Then teachers in any field be able to promote students' conceptual understanding.

Previous studies have pointed out that students are not capable of having Conceptual change as a result of teacher instruction. However, old theories that emphasize the incapacity of the students to facilitate conceptual change of biology concepts are nowadays being questioned (Abd-el-Khalik and BouJaoude (1997).

Teachers whose knowledge is more implicit, coherent and integrated, tend to teach the subject more dynamically, represent it in more varied ways, and encourage and respond fully to students' comments and questions. But when knowledge is limited, the tend to depend on the text for content, de-emphasize interactive discourses in the form of seat work assignment and, in general, portray the subject as collection of static and factual knowledge (Brophy, 1991). in this contention, meaningful understanding of the concepts in biology depends on teacher delivery of their subject matter to students. Learning to be meaningful, requires understanding of concepts and acquiring new meaning after formulation of non-arbitrary and verbatim relationship among ideas in the existing relevant aspect of the learner's cognitive structure (Carvallo and Shaper, 1994).

If teachers are incapable of representing content knowledge, they cannot help in their students desired learning. If teachers can represent well the concept to students, it is possible that students as well can represent their ideas based on teacher's representation. In this aspect, the student representation of knowledge can be captured through the help of writing. Fellows (1994) asserted that student's writing is a potential source of representation of their ideas, which changes during science lessons.

In Iligan city and Lanao del Norte in the Philippines result of National Achievement Test (NAT) and National Career Assessment Examination (NCAE) is very frustrating; students found to have very low performance in areas of Science, Mathematics and English. In this study, the researcher try to look into the problem in lens of a teacher as instructional developer of knowledge by looking into their representation of Pedagogical Content knowledge inside the classroom. Representation of content knowledge in this study refers to how the teachers present their ideas of the topic inside a biology classroom and on how skillful they are in attaining knowledge attainment among students in presenting their declarative and procedural knowledge. Theoretically, this study assumes the idea of constructivism where the theory that says learners construct knowledge rather than just passively take in information. As people experience the world and reflect upon those experiences, they build their own representations and incorporate new information into their pre-existing knowledge (schema). This means that if the teacher is able to represent his/her ideas both content and methods to the students, it reciprocates that the students can apply what the teacher teaches and learn from him/her.

This is a qualitative-quantitative research, where the main concern is to investigate pedagogical content knowledge representation of Biology Teachers and determine the effect and/or subsequent relationships with the student conceptual understanding.

METHODOLOGY

The subject of the study was three (2) junior and two (2) senior high biology teachers in the Department of Education, one (1) private high school and one (1) biology teacher in State University Laboratory School. A total of six (6) respondents were used in this study. This purposive sampling was done to facilitate representation of different school types in the area of concern.

There were five biology topics studied in this research. These include the following: (1) Cellular Respiration; (2) Photosynthesis; (3) Human Reproduction; (4) Mendelian genetics; and (5) Non-Mendelian Genetics. The selection was based on the following: (1) the topics are easily integrated and conceptualized using concept maps; and (2) the topics are slightly difficult to teach because the teacher has to have some in-depth knowledge about the topic. The study utilized classroom discourses in these five biology topics during classroom observation among biology teachers. A total of 30 classroom discourses, five (5) discourses were analyzed per topic. Teacher's pedagogy was analyzed using a five-point checklist developed by Ravina (2001) which was validated for consistency and reliability during her study. Motivational Activities were analyzed using classroom discourses dialogue between the students and teacher in the 30 discourses. Assessment for learning, assessment of learning and assessment as learning were inspected in the dialogue between the teacher and students in the discourse and were categorized if it assesses higher order thinking skills of not. It also scrutinized the manner of how the question is asked, wait time and tools used during classroom discourses. Representation of Content knowledge in this study refers to how the teacher showed their expertise in the biology topic in presenting their ideas about the topic. For example, how he/she explains and presents the declarative and procedural content knowledge in genetics. These were measured by analyzing classroom discourses by looking into how the teacher represents his expertise of the topics. The study looks into declarative knowledge by how the teacher bring the concepts of the topic in their classroom through different methods of teaching while procedural knowledge was scrutinized during the conduct of their laboratory and other solving problem activities. Moreover, the researcher utilized experts (say, a PhD in genetics inspect the correctness of content knowledge of teachers based on the classroom discourses transcripts) to look into correctness of the concepts on biology. Also, the researcher examined the definition, the defining attributes, the example and non-example, the taxonomy of the concept, the statement of principles and the vocabulary provided by the teacher during classroom discourses. Likewise, the four successive levels of concept attainment suggested by Klausmeier (1974) are determined based on the criteria shown in Table 1.

Qualitative data using classroom discourses were utilized to describe patterns of teacher's activity inside the classroom. These are determined by identifying and describing the patterns in classroom discourses of the topics mentioned. Observed patterns are on classroom pedagogy, motivational skills, assessing skills and content representation of Biology topics. Moreover, Quantitative data utilized in this study are the scored concept maps made by both teachers and students to determine congruence of knowledge representation of teachers and conceptual understanding of students using maps scored by structural and relational scoring used by Barquilla (2018). Coding of data with the use of three combination letters was used to hide the identity of the respondents being part of ethical consideration.

Table 1. Patterns of Students-Teacher Interaction inside Biology Classroom

Level of Concept Attainment	Description
Concrete Level	• Attending perceptible features of thing, object or event. • Discriminating the thing, object or event from other things, objects or events. • Remembering the discriminated thing, object or event
Identity Level	• (Concrete level above) plus: • Generating that two or more forms of things are the same object.
Classificatory Level	• (Concrete level) • (Identity level) plus: • Generalizing that two or more example are equivalent and belong to the same class of thing.
Formal Level	• (Concrete level) • (Identity level) • Classificatory level) plus: • Discriminating Attribute of the class • Hypothesizing relevant attribute and/or rules, remembering hypothesis and evaluating the hypothesis using positive and negative instances. • Cognizing the common attributes and/or rules in positive instances. • Inferring the concepts

RESULTS AND DISCUSSIONS

Biology Teachers' Pedagogy

The pedagogy of teachers inside the classroom is determined with the use of an observation checklist and classroom discourses. For instance, the teachers' pedagogy was determined using a five-point scale checklist where 1 is the lowest and 5 is the highest as illustrated Table 2.

Table 2. Description of Pedagogy Used by Biology Teachers in Classroom discourses.

Scale	Description*	Percentage of Pedagogy used by Biology Teacher (n=30 discourses)
1	Pure one-way pedagogy (The teacher makes no attempt to monitor students learning through oral questioning)	0
2	Predominantly one-way pedagogy (the teacher accept choral answer to questions)	0
3	Initial step towards two-way pedagogy (The teacher directs some questions to individual students, but does not use their responses formatively in the discussion.)	(13) 43%
4	Incomplete two-way pedagogy (The teacher directs many or most questions top individual students, occasionally uses those responses formatively.)	(16)53%
5	Full two-way pedagogy (There is effective dialogue between teacher and students in construction of knowledge and concepts.)	(1)4%

*Ravina (2001)

Table 3 presents the pattern of teacher's type of pedagogy used inside the classroom. Of the 30 classroom discourses, 16 (53%) incompletely two-way pedagogy, meaning, the teacher directs many or most questions to individual student but occasionally uses those responses formatively. On the other hand, 13 (43%) have initial step towards a two-way (I.e., biology teachers direct some questions to students but do not use students' responses formatively in the discussion. While only one or 4% utilize a full two-way pedagogy. This implies that biology teachers lack an effective dialogue between them and their students in the construction of knowledge and concepts.

Table 3. Patterns of Students-Teacher Interaction inside Biology Classroom

Type of Teacher-Student Interaction	Frequency	Percentage (%)	Qualitative Description
Teacher-dominated	29	97	Mostly teacher talks/activities
Student-dominated	0	0	Mostly Student talks/activities
Teacher-Student Dialogue	1	3	Equal proportion of teacher and student talks/activities
Total	**30**	**100**	

Furthermore, the types of classroom interaction inside the biology classroom are shown in Table 2. Once again, teacher-student interaction is based on classroom discourse. Cross-validated by an observation checklist. Student-teacher interaction is determined and classified based on the ratio of student and teacher activities/talk inside the classroom. Results reveal that 97% of the discourses are teacher dominated. There are more teachers talk or activities rather than student activities.

This result suggests that biology teachers' type of pedagogy reflects the intention inside biology classrooms. The incomplete two-way pedagogy does not promote good interaction between students and teachers. Teachers tend to dominate the activities, which does not facilitate good dialogue between the learner and speaker and, as a consequence, does not develop and promote teacher's pedagogy can be generally stated as teacher-dominated and incomplete two-way pedagogy.

Biology Motivational Activities

Teachers' motivational activities can be done any time within the class period. Based on the data gathered, all the teachers provide initial motivation to students prior to the introduction of the topical conception.

Table 3 summarizes the opening motivational activities and skills to the five topics observed from the six teachers. It can be said that the teachers use various methods of initial motivational activities to stimulate students' interest in the topic. For example, an opening motivational activity used by Teacher FTC in Discussing the topic photosynthesis started with the history and Philosophy of science to interest the students on the development of a scientific invention. On the other hand, the use of visual demonstration and asking questions about the topic to stimulate students' visual activity (to stimulate/ignite thinking skills through analytical thinking about the diagram) are among the initial strategies used by other biology teacher. Such strategies were used by Teacher RTL, JTB and JTM. While others used previous knowledge as springboard for introducing the new topic.

Moreover, Table 4 presents the motivational skill and strategies utilized by the biology teachers during the opening of the class discussion. Teacher JTM for instance, conducts a laboratory activity to facilitate the discussion in Photosynthesis. Science Teachers are, in fact, expected to be knowledgeable about this technique as well as the content knowledge to be able to discuss the results of the laboratory activity and connect the main idea to the main topic.

Biology teachers use different strategies depending on the topic and the appropriateness of the strategies.

Generally, biology teachers utilize different opening motivational strategies. To summarize, these strategies are: (1) reviewing the previous lessons and relating to the present topic (40%); (2) starting with definition and elaborating it (14%); (3) using an actual example (14%); (4) using an illustration (10%); (5) using a passage in a textbook related to the topic (6%); (6)using laboratory activities and relating them the present topic (3%); and (7) using PROBEX (predict-observe-explain) technique to ignite the students' interest (3%).

Meanwhile, about 50% of the teachers use the following motivational strategies in their classroom planning more activities that cater to students' interest and requiring students to relate the previous topic with new topic.

About 30% utilize the following motivational activities: providing encouragement to students with low performance, offering rewards as incentives for performing well; structuring appropriate and healthy competition, giving more opportunities for student to participate, applying novel and interactive instructional method, asking questions related to the assignment, and reviewing the previous lesson and relating it to the new lesson.

About 10% use history and philosophy of science in stimulating interest in the topic.

In general, the clinical interview, lesson plan, classroom discourse transcripts and observation show that the teachers follow a logical sequence in putting motivation and strategies in their lesson. The motivational strategies start even before the lesson implementation. For instance, teacher FTC and CTC identify the objectives for the lesson and provide meaningful learning activities based on the identifies objectives. From there, they select the appropriate opening stimulating activities relevant to the lesson. Considering the learning objectives and the importance of the topic to everyday life, they prepare instructional materials so that the lesson (especially if it involves abstract concepts) becomes concrete to the students. The motivational strategies used by all the teachers are as follows: (1) identifying meaningful learning objectives for the topic; (2) Starting stimulating activities relevant to the lesson; (3) Pointing out the importance of the lesson in daily activities; (4) Providing students with concrete instructional support; and (5) Presenting abstract concept concepts concretely in a more personal and familiar manner.

Meanwhile, other motivational activities used by some teacher are: planning more activities that cater to students' interests and requiring student to relate the previous topic with the new topic, providing encouragement to low performers, offering rewards as incentives to performing well, encouraging appropriate and healthy competition, giving more opportunities for the students to participate, applying novel and interactive instructional methods, asking questions related to the assignment, reviewing the previous lesson and relating it to the new lesson, and using history and philosophy of science in stimulating student interest on the topic.

Biology teachers' Assessment

Teacher assessment of students' learning can be in the form of questions evaluating students' understanding. This can be done after the class discussion or during the learning process itself. In this study, questions of teacher while developing conception were counted, evaluated, and classified based on the type of questions.

There were 628 assessment questions identified from thirty classroom discourses. Assessment questions were classified according to whether the question requires higher order thinking or simple recalling. Results in Table 5 show that about 50% of the questions qualify as higher-order thinking questions. These are distributed into critical thinking questions which analyses arguments (23%), problem solving which analyze alternative solutions (17%), decision-making questions which pertain to making a choice from a number of options (12%) and creative thinking question (0.48%). However, it is apparent in the data of the five types of questions, that majority are simple recall (48%).

Table 4 further classifies questions as to whether these are divergent or convergent. A convergent is one that requires one exact answer, while divergent question requires varied answer. Of the 628 questions asked by the teacher in the process of teaching, there were 267 (58.4%) convergent questions, and 261 (41%) divergent questions.

Table 4. Distribution and Classification of Assessment Questions Generated by Biology Teachers during Classroom Discourses

Types of Assessment Questions	**TOPIC**						
	P	**CR**	**HRS**	**MG**	**NMG**	**f**	**%**
Problem Solving	0	12	0	44	50	106	**16.90**
Creative Thinking	0	3	0	0	0	3	**0.48**
Analytical thinking	24	7	16	20	6	73	**11.62**
Critical Thinking	25	40	35	13	31	144	**22.92**
Simple Recall	76	72	67	46	41	302	**48.08**
Total	**125**	**134**	**118**	**123**	**128**	**628**	**100**

In addition, Table 5 provides the data on the teachers' manner of questioning. As revealed in the Table, sixty percent are specific questions to a particular concept discussed in class. In 53% of the questions, the teacher gave time for students to think before responding. The wait time ranged from 2 to 40 seconds depending on the kind of questions. Generally, however, the average is about 12 seconds. A 12 second wait time is necessary to allow students, especially a slow learner, to organize his/her thoughts. In most cases, whenever a student cannot answer the question, the teacher usually repeats it or rewords it or asks leading questions. This implies that that teachers provide enough chance for the student to answer correctly. However, this is not done as often as desired, the frequency of phrasing or rephrasing clearly in Table 5 is only 53%.

Meanwhile, some of the teachers asked questions that encouraged participation of students (3.18%).

Table 5. Manner of Questioning of Biology Teachers during Classroom Discourses in Five Biology Topics

Manner of Questioning	**Frequency**	**Percentage**
1. Phrases and rephrases the question clearly	335	**53.3**
2. Asks specific questions	377	**60.0**
3. Give the Students to think before responding. Average wait-time: 11.8 seconds (Range: 2-40 seconds)	334	**53.1**
4. Ask questions that encourage students' participation (N=626)	20	**3.18**
5. Encourages Students to ask question and answer them	17	**15.7**
6. Asks convergent questions (N=628)	367	**58.4**
7. Asks divergent questions (N=628)	261	**41.6**

As shown in the sample questions, the teacher tries to encourage the students to participate in the classroom discussions. However, it is sad to note that only about 17% out of 108 (15.7%) teachers encourage students to ask questions and answer them. This low percentage means that teachers did not sufficiently encourage two-way communication during discussion.

Table 5. Assessment Tool used by Biology Teachers

Tool Used	Frequency	Percentage (%)	Rank
Pencil and Paper testing	14	47	**1**
Rating Students' class participation	0	0	**6**
Giving homework/Assignment	0	0	**6**
Student-teacher conference	0	0	**6**
Asking questions during class discussion as sort of evaluation	8	37	**2**
Oral testing after the lesson has been presented	3	10	**4**
Essay Writing	5	16	**3**

Table 5 gives a ranking of assessment tools based on frequency of use by Biology teachers. As shown, forty seven percent use traditional pencil-pen testing, which ranks first. This result suggests that the teachers still rely on the traditional method of assessment. Thus, they need to attend in-service training to learn more modern techniques in students' evaluation and assessment such as portfolio assessment, concept mapping, and other authentic assessment tools.

Biology Teachers' Representation of Declarative and Procedural Knowledge

Looking into how the biology teachers represent concepts inside the classroom provides insight for in-service teacher training of biology teachers to improve teaching and learning. Declarative knowledge of biology teachers is based on their proposition, imagery, and linear ordering as they together form their representation into a schema.

The researcher utilized experts to investigate the correctness of the concepts on biology. Moreover, the researcher examined the definition, the defining attributes, the example and non-example, the taxonomy of the concept, the statement of principles and the vocabulary provided by the teacher during classroom discourses. Likewise, the four successive levels of concept attainment suggested by Klausmeier (1974) are determined.

Figure 1 gives the concept analysis by Teacher JTB. This concept analysis has the nearest representation of core proposition to that of the expert. It can be said the teacher's concepts about photosynthesis have reached the formal level of concept attainment. Examining the teacher's proposition about photosynthesis complied with the criteria set in the formal level. For instance, the teacher has attended the perceptible features of the event. She is able to discriminate between the different events that occur in the photosynthesis process. She generalized that the two phases of photosynthesis (Light and Dark) are part of the same process. She generalized that that two or more examples (plant, algae, photosynthetic bacteria) are equivalent and belong to the same class of thing (I.e., autotroph), discriminated the attributes of the class (autotroph) from those non-examples (heterotroph); hypothesized that all organisms that have chlorophyll are capable of photosynthesis.

This teacher also identified and differentiated examples and non-examples (Classificatory level). She established the correct terminology for the concept and its attributes during discussion. Acquiring the names of concepts and their attribute facilitates the attainment of concept at the higher level: formal level.

Analysis of Photosynthesis

A. Definition:

Photosynthesis is a process by which plants with the use of light energy and chlorophyll produce glucose, water and oxygen.

B. Defining attributes:

Process in chlorophyll-bearing organisms; use of energy and chlorophyll; production of glucose, oxygen and water; dark and light reactions; process taking place in chloroplasts

C. Irrelevant attributes:

Heterotrophs, the rest of the solar spectrum

D. Examples:

Autotrophic organisms: plants, algae, photosynthetic bacteria, etc.

E. Non-examples:

Heterotrophs, man

F. Taxonomy:

Supraordinate: Photosynthesis

Coordinate: In the presence of light and chlorophyll, water + carbon dioxide → glucose + oxygen + water

Subordinate: Light reaction (Photoactiviation, Photolysis); Dark reaction (Carbon dioxide fixation)

Taxonomy relationships:

1. Photosynthesis is a plant process of combining water and carbon dioxide in the presence of light and chlorophyll, producing glucose , oxygen and water.
2. The process involves light reaction and dark reaction.
3. Light reaction includes photoactivation and photolysis.
4. The products of photolysis are needed in carbon dioxide fixation.
5. The dark reaction involves carbon dioxide fixation.

J. Statement of principles (Teachers propositions):

1. Photosynthesis is a plant process of combining water and carbon dioxide in the presence of light and chlorophyll, producing glucose, oxygen and water.
2. Autotrophs are organisms that make their own food. Heterotrophs are organisms that depend on other organisms for food.
3. The equation for photosynthesis is as follows: $6CO_2 + 12H_2O \xrightarrow[chl]{light} C_6H_{12}0_6 + 6O_2 + 6\,H_2O$
4. In the light reaction, water undergoes photolysis due to the absorption of solar energy by chlorophyll. The chlorophyll is energized, causing the water to be photolyzed into H ions and oxygen.
5. The chloroplast is the photosynthetic machinery of the cell. It has grana and stroma. Chlorophyll, which is embedded in the grana of the chloroplast absorbs light energy. The grana are the sites for the light reaction and the stroma, for dark reaction.
6. In the dark reaction, the products of light reaction are needed to continue the process. Therefore, the dark reaction is dependent on the light reaction.

K. Vocabulary: Photosynthesis, chloroplast, photoactiviation, photolysis, carbon dioxide fixation, dark reaction, light reaction, chlorophyll

Figure 1. Concept Analysis of Photosynthesis, Teacher JTB

In this topic, most of the teachers provided the students with the same concepts and principles. In fact, some of the teachers like Teacher JTM were able to provide the application of the concept, encourage and guide student’s discovery and independent evaluation by using the laboratory approach in her teaching. Thus, the teachers were able to provide formal level concept attainment to their students. This data imply that the teacher declarative knowledge in photosynthesis is sufficient to facilitate attainment of formal knowledge and therefore enhancement is not necessary.

Accordingly, students learn the teacher’s declarative knowledge in three episodic sequences: (1) teacher declares his/her proposition/ideas; (2) provides imagery of his proposition/ideas; and (3) connects sequences and arranges the proposition in linear order. These three episodic sequences encompass his schema in teaching a topic. In this study, the researcher scrutinized the declarative knowledge of Biology teachers and found out the following finding as follows:

<u>*On Concept analysis:*</u>

1. The teacher's declarative knowledge in photosynthesis is sufficient to facilitate attainment of formal knowledge and therefore further enhancement is not necessary.
2. Some teachers, however, promote student concepts attainment up to identity level only, particularly on the topic cellular respiration and human reproductive system.
3. Some teachers are able to attain formal level, however, they do not have adequate information about the key concepts. This was observed particularly on the topic genetics.

<u>*On Proposition and Linear ordering*</u>

1. In photosynthesis, the teachers' concepts are almost similar to the expert's core concepts. The essential concepts are the definition of photosynthesis, the chloroplast, the light and dark and the dependence of the dark reaction on the product of light reaction. (However, there are concept errors in the list of propositions). There are also some concepts added by the teachers in their discussion aside from essential concepts suggested by experts (e.g., type of nourishment in the environment). This observation is also true in the other topics studied.
2. The teachers represent ideas in different forms and styles. Some represent ideas on logical sequence (I.e., definition of terms and the rationale about the sequence of the topic are discussed first to help the student understand each concept better. Others focus directly on the main content ideas.
3. It seems that the teachers who have master's degree and master's units in Biology have almost similar propositions and sequences to those of the experts.
4. Most of the teachers come up with inadequate propositions particularly genetics (Mendelian and Non-Mendelian) and Human Reproductive system. There are also core concepts recommended by the expert that are not found in the teachers' list of propositions. The teachers' proposition contain some misconception.
5. The teachers are knowledgeable in Photosynthesis and respiration; but they need improvement in other topics, such as genetics and reproduction, implying the need for further training or studies.

<u>*On Proposition and imagery*</u>

1. They utilize six methods to construct meaning of concepts: (1) simply defining; (2) using students' imagination; (3) using diagram or chart to define meaning; (4) using laboratory activities to construct meaning; (5) using natural phenomena as bases of constructing meaning; and (6) using quotation from textbook to construct meaning.
2. They use three methods to represent classification: (1) use of chemical equation to identify similarities and differences; (2) use of chart to illustrate difference; and (3) listing the differences and similarities.
3. They use four methods to represent relationship: (a) use of drawing and schematic diagram to identify part; (use of drawing to demonstrate sequence of event; (c) use of biography/history in tracing the development of the concept; and (d) tracing the steps in a process.
4. The use seven method to represent transformation: (a) use of practical problem; (b)use of chart to facilitate generic crossing; (c) use of mathematics to solve problem; (d) use of chemical equation;(e) laboratory experiment; (f) previous knowledge to solve problem and (g) use of diagram to analyze events.
5. They use three methods to represent causation: (a) use of Laboratory activity to demonstrate effect; (b)us of historical development to predict results and © use of mathematical deduction to interpret results.
6. They often modify definition and discussion in the textbook and express this in *Lingua franca* to be better understood by students.

7. The teachers' analogs given to students far from the things, object, event, or processes being compared to. This suggests that the teacher sometimes provides the condition for students' developing alternative conception through analogy/metaphors that they give.

<u>On Schema</u>

1. The teachers deviate from the lesson plan to accommodate students' interest and adjust to the actual situation during the lesson presentation. Thus, teacher needs to depend solely on their planned lesson but consider also other factors such as availability of facilities, actual classroom conditions, learner's preparedness for the lesson and other contributory factors that might affect their teaching during lesson implementation. This implies the need to anticipate such factors as well as they need to provide alternative plans (e.g., Plan B, Plan C) in case of emergency.
   Procedural knowledge is the second type of knowledge representation. It involves a specific procedure or set of action to accomplish the set goal. What the teacher does depends on the goal structure or specific step required. In this study procedural knowledge was studied only in connection with the way the teacher teaches how to solve problems. The data sources Indicate that teachers give problems that they have solve beforehand. They provide students with sequences of steps in a problem-solving lesson to facilitate analysis. They conduct laboratory activities for the purpose of verifying rather than discovering something new in connection to the topic to be taken in class. This defeats the purpose of laboratory activities. Only a few teachers use laboratory activity to represent a topic; and this is done only in connection with photosynthesis. The other teachers use only "thought experiment" and other representation techniques.

Congruence of Teachers and Students knowledge Structure

To statistically test the congruence of teacher's representation and student conceptual understanding before and after each representation of topic, the researcher utilizes non-parametric Kendall's tau Coefficient of agreement test. Table 6 shows the statistical analysis of agreement of teacher representation (based on their concept maps ranking scores) and student conceptual understanding (based on their post-instructional concept maps ranking scores).

Table 6. The Relationship between Teachers Representation and Student Conceptual Understanding as determine by Kendall's Tau

Topic	Computed Values				Interpretation
	Agreement P	***Inversion Q***	***Space***	***Tau***	
Photosynthesis	11	3	8	**.533**	Moderate of substantial agreement
Cellular Respiration	9	6	5	**.333**	Littl or small agreement
Humsn Reproduction	11	1	10	**.667***	Moderste or sunstanttial to high agreement
Mendelian Genetics	12	4	7	**.477**	Moderste or substantial agreement
Non-Mendelian Genetics	13	2	11	**.773***	Moderte or substantial to high agreement
All Topics	9	1	8	**.80***	High agreement

*Significant at alpha= 0.05

Table 6 is actually the Kendall's Tau coefficient result of each of the five topics. The hypothesis tested at alpha=.05 is that there is no significant relationship between the rankings of students' post instruction concept maps scores (Student conceptual

Understanding) and teachers' Concept maps after their lesson (Teacher Representation). Result indicates that all topics tested have moderate or substantial agreement, except in cellular respiration that has only little or small agreement. It is interesting however that, of the five topics, human reproduction and Non-Mendelian Genetics are significantly correlated at alpha= 0.05, the latter being highest at .773. What is noteworthy is the fact that Barquilla (2002) results that teachers are least knowledgeable in genetics seemed to contradict this result. It is highly probable, therefore, that they exerted extra effort to make their representation of genetics concepts interesting and challenging to students that the latter understood the concept clearly.

The results suggest that most of the topics (Photosynthesis, human reproduction, Mendelian, and Non-Mendelian Genetics) studied have moderate or substantial agreement between two groups. Pooling all topics, however, it is shown that there is high agreement between the teacher representation and students' conceptual understanding. Hence, the results suggest that teachers' representation does influence students' conceptual understanding.

CONCLUSION AND IMPLICATIONS

The study identified emerging patterns in this group of teachers. It is concluded that:

1. The teachers use the following strategies: (a) having meaningful learning objectives; (b) starting the class with stimulating activities relevant to the lesson; (providing student with concrete instructional material support; (d) presenting abstract concepts in a more personal and familiar concrete manner; and (e) finding application to the lesson in daily activities.
2. They spend more time in genetics (Mendelian and Non-Mendelian) as compared to those other topics under study. This must be due to the nature of the topics which require more time for analysis because of mathematical component.
3. They usually employ incomplete two-way pedagogy and teacher dominated student-teacher interaction, which does not develop and promote students' higher order thinking.
4. Most of the assessment questions of the teachers are simple recall and convergent questions. Furthermore, they rely on traditional methods of assessment.
5. During class discussion, the teacher does not always give students sufficient time to answer the questions they ask. Moreover, only a few encourage the students to ask questions themselves and answer them.
6. Teachers have their own unique teaching styles and strategies in promoting student conceptual understanding. Such teaching strategies and styles influence the teaching situations, the nature of the topic they discuss and belief in what strategies best fit the situation to make the student understand the topic they are teaching.
7. The teachers utilize six (6) methods to construct meaning of concepts, three (3) methods to represent classification, four (4) methods to represent relationship, seven (7) methods to represent transformation and three (3) methods to represent causation.
8. The teacher analogs given are sometimes far from the things, object, events or processes being compared.
9. They give the students only the problem that they have solved beforehand. They provide students with the sequences of steps in a problem-solving lesson to facilitate analysis.
10. They conduct laboratory activity for the purpose of verifying principles rather that discovering something new in connection to the topic to be taken up in class; and
11. Teachers' representation of Pedagogical content knowledge highly influences individual student conceptual understanding.

Based on these conclusions, it is implied that teachers in this area of concern need retooling and upgrading in order that the problem at hand of low performance of student can be properly address. The study identified weakness and strength of teachers as to their representation and pin down focus of teacher's training needs to facilitate improvement in student performance as the effects of teachers' representation. The Department of Education as the head agency for teachers' transformation may consider this study as basis for developing teachers training. Likewise, teachers may reflect their PCK if they were able to transform students' learning after their lesson implementation as they assess the overall impact of their lesson.

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