Relationships Between Teachers' Representations and Students Conceptual Understanding of Some Biology Topics

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Abstract

The study explores the possibility of establishing the congruence of teachers' (n=6) representations of content knowledge and students' (n=222) conceptual understanding of some high school topics in biology. It aims to determine the subsequent effect of teachers' representation of content knowledge on students' conceptual understanding and establish their relationship. Relationship in this study refers was matching of the students' with the teachers' representation of content knowledge. This is done by comparing what the teacher have in mind (as expressed in their concept maps) with what the students have in mind (as expressed in their concept maps) and determining whether there is agreement in the concept of the two groups.

The results of the correlation analysis indicate a Kendall's Tau value of .80 significant at α = .05 when all topics are combined. The highest Kendall's Tau coefficient value among the topics studied is .733 in Non-Mendelian Genetics, which was considered as the least knowledgeable topic in the teachers' knowledge structure (Barquilla, 2002).

It is highly probable, therefore, that those teachers exerted extra effort to make their representation of genetics content interesting and challenging to students, to the point that the latter understood the concept clearly.

Keywords: Teachers' Representation, Conceptual Understanding, Instructional Ability

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Introduction

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

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 concept are nowadays being questioned. For example, Abd-el-Khalick and Boujaoude (1997) claim that teachers are capable of transforming their knowledge and understanding of science concept to the students. They say that, without such transformation, teachers knowledge' and understanding would remain virtually tacit for teaching. Thus, today's science education reforms to accentuate the significance of teaching students to be critical thinkers.

Teachers whose knowledge is more explicit, 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, they tend to depend on the text for content, de-emphasize interactive discourses in the form of seatwork assignment and, in general, portray the subject as collection of static factual knowledge (Brophy, 1991). In this contention, meaningful understanding of the concepts in biology depends on the teachers' delivery of their subject matter to students. Learning, to be meaningful, requires understanding of concepts and acquiring new meaning after formulation of nonarbitrary and non-verbatim relationships among ideas in the existing relevant aspect of the learner's cognitive structure (Carvallo and Shafer, 1994).

If teachers are incapable of representing content knowledge, they cannot help in their students' desired understanding. 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, insights and understanding of the conception. In this respect, the students' representation of knowledge can be captured through the help of student writing. Fellows (1994) asserted that student's writing is a potential source of representation of their ideas, which changes during science lessons.

This study looks into the effects of teachers' representation and/or subsequent relationship with student conceptual understanding of biological topics in classroom discourses.

Methodology

Study Area and Sample

The area of Iligan City and Lanao del Norte is located at the central part of Mindanao, Philippines and is geographically situated 7°57' to 12 North Latitude and 123°38' East Longitude. The site locations of the schools of this study are mapped out in the geographic sketch labeled Figure 1.

The subjects of the study were the second year secondary high school teachers and students. The secondary schools involved were: (1) Science High Schools (*e.g.*, DepEd-supervised Science High School, SUC Science Laboratory Schools) and (2) SEDP Curriculum High Schools (*e.g.*, DepEd Nationalized High School and private Secondary High Schools). Schools were selected on the basis of the two types of high school curricula. Whenever there were more schools in each school type, the researcher employed random sampling techniques among schools. However, the school that represents only a particular school type automatically became the school representative.

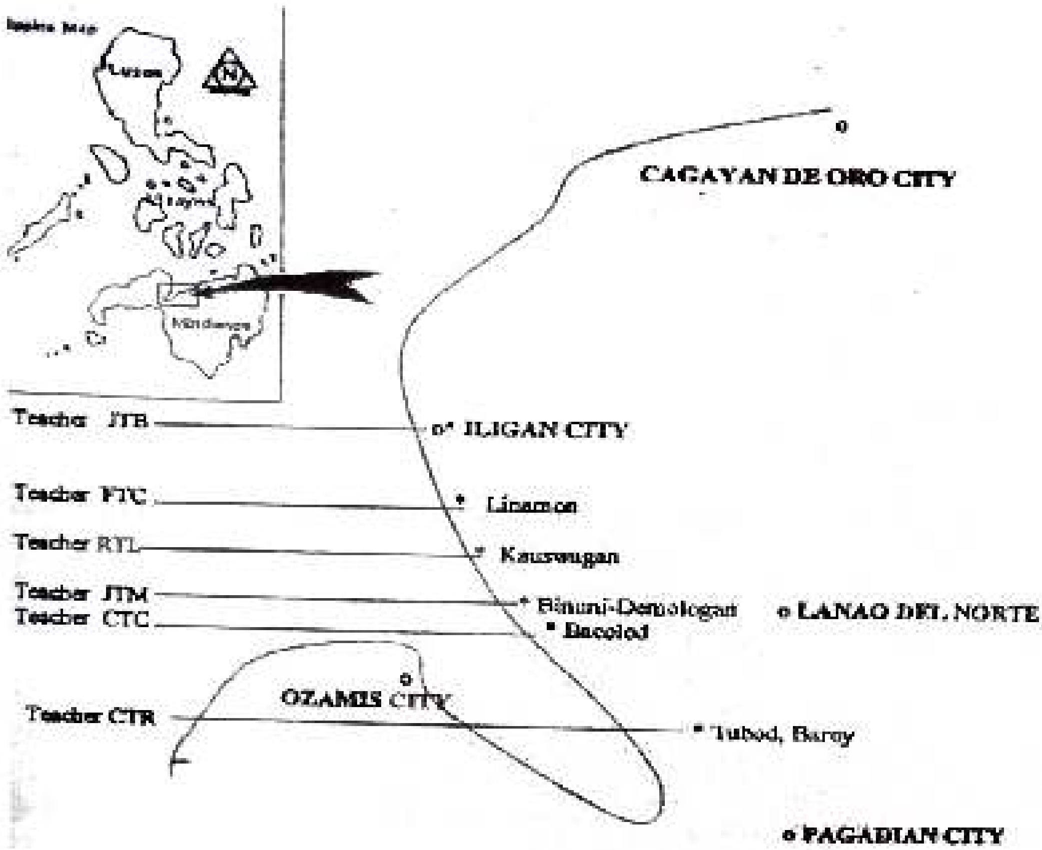


Figure 1. Geographical Sketch of Site Location of Schools

Ten schools were selected among secondary high schools of Iligan City and Lanao del Norte. For each school type, two teachers were randomly selected among the biology teachers. However, MSU-IIT Laboratory School that represents a sole type of curriculum all over the area was duplicated by selecting two teacher representatives. The purpose of this duplication was to come up with replicates such that, if one set of data would be invalidated, there is still a representative of that particular set of data. For student selection, those who belong to the teacher-respondent's class were automatically the student respondents. There were 35 to 44-students per classroom..

From the original ten schools chosen to constitute the sample, only six biology teachers completed the five topics intended for the research. Two completed only three topics, while the rest had only two topics. Thus, the data of those teachers who did not complete the five topics were not included in the analysis. There were a total of 222 student-respondents cluster sampled from these biology classes.

The Biology Topics

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 were the remaining themes of biology for the third and fourth quarter of the syllabus; (2) the topics are easily integrated and conceptualized using concept maps; and (3) the topics are slightly difficult to teach because the teacher has to have some in-depth knowledge about the topic.

The Instrument and the Data Gathering Procedure

The main tool in collecting data in this study was the use of concept maps. Teachers and students were provided lecture on how to make concept maps prior to data collection. The researcher allotted one month for the lecture just to ensure that every student and teacher knows how to make concept maps. During the data collection, concept maps of teacher were collected one hour before lesson representation of the topic and students were collected pre- and post-instruction concept maps.

The conceptual knowledge structures of students and teachers were measured using concept maps, which were scored based on the following scoring methods. Figure 2 provides the protocol for the **relational scoring** (*i.e.*, relationship of concepts) of students' concept maps. The diagram may be interpreted with the help of Figure 3. The boxed questions in Figure 2 are as follows:

1. *Is there a relationship between the key concept/proposition and each general concept in the First Level of Figure 6.2?* To tackle this question, the researcher answered a *supplementary question*, "How does one know if there is a relationship between the key concept and each general concept?" *Answer*: " There is a relationship IF a general concept has any of the elements of the key concept."

   E.g., Key Concept: PHOTOSYNTHESIS

   The general concepts (First Level) are related to this key concept if they are describing the process, raw materials, products, presence of chlorophyll and sunlight, or site of photosynthesis.
2. *Does the label (or linking phrase/word) indicate a possible relationship between a first level concept and a second level concept?* This is so if the label correctly links the two concepts.
3. *Does the direction of the arrow between two concepts in successive levels indicate a hierarchical, causal or sequential relationship between the two concepts?*

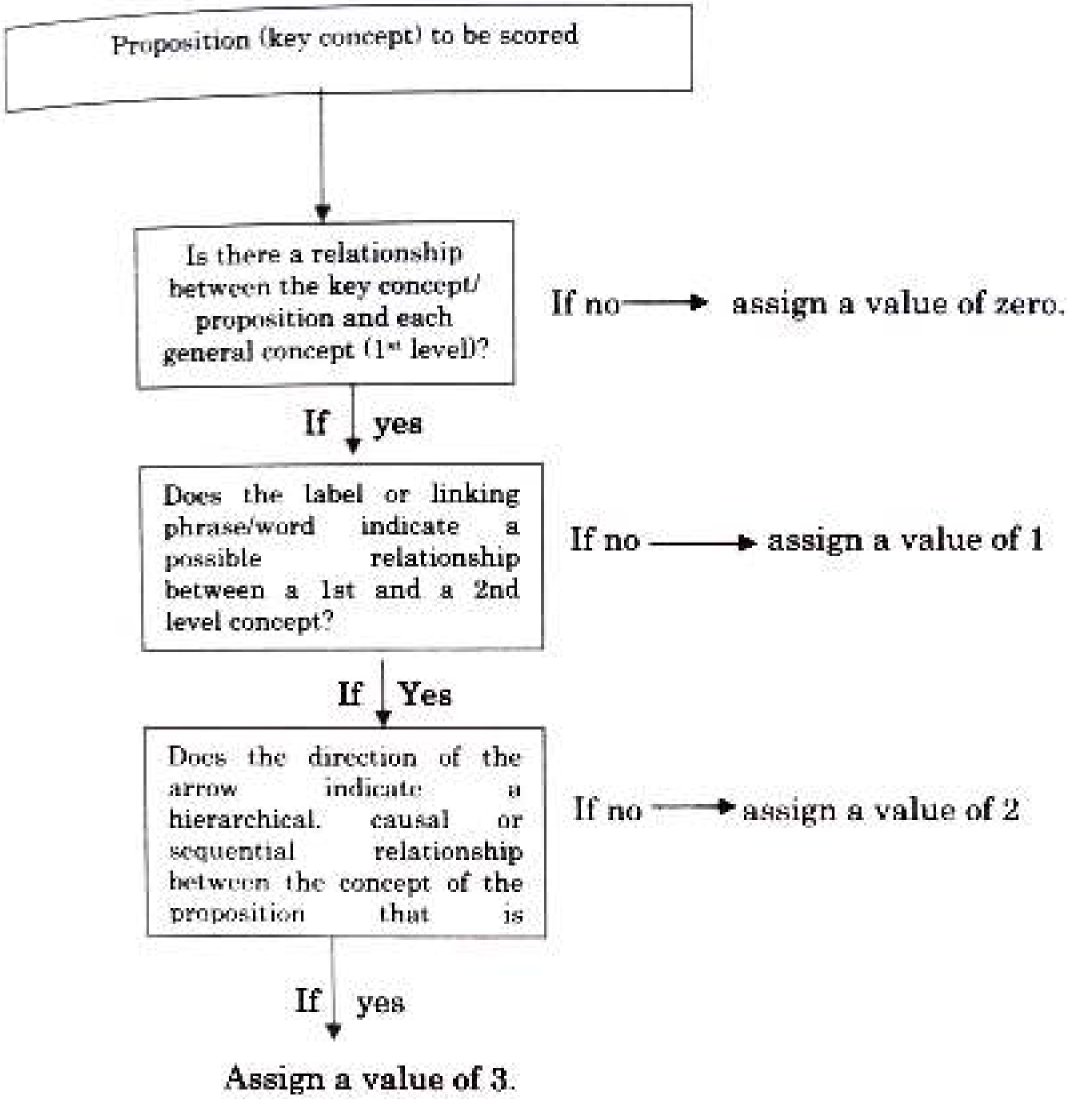
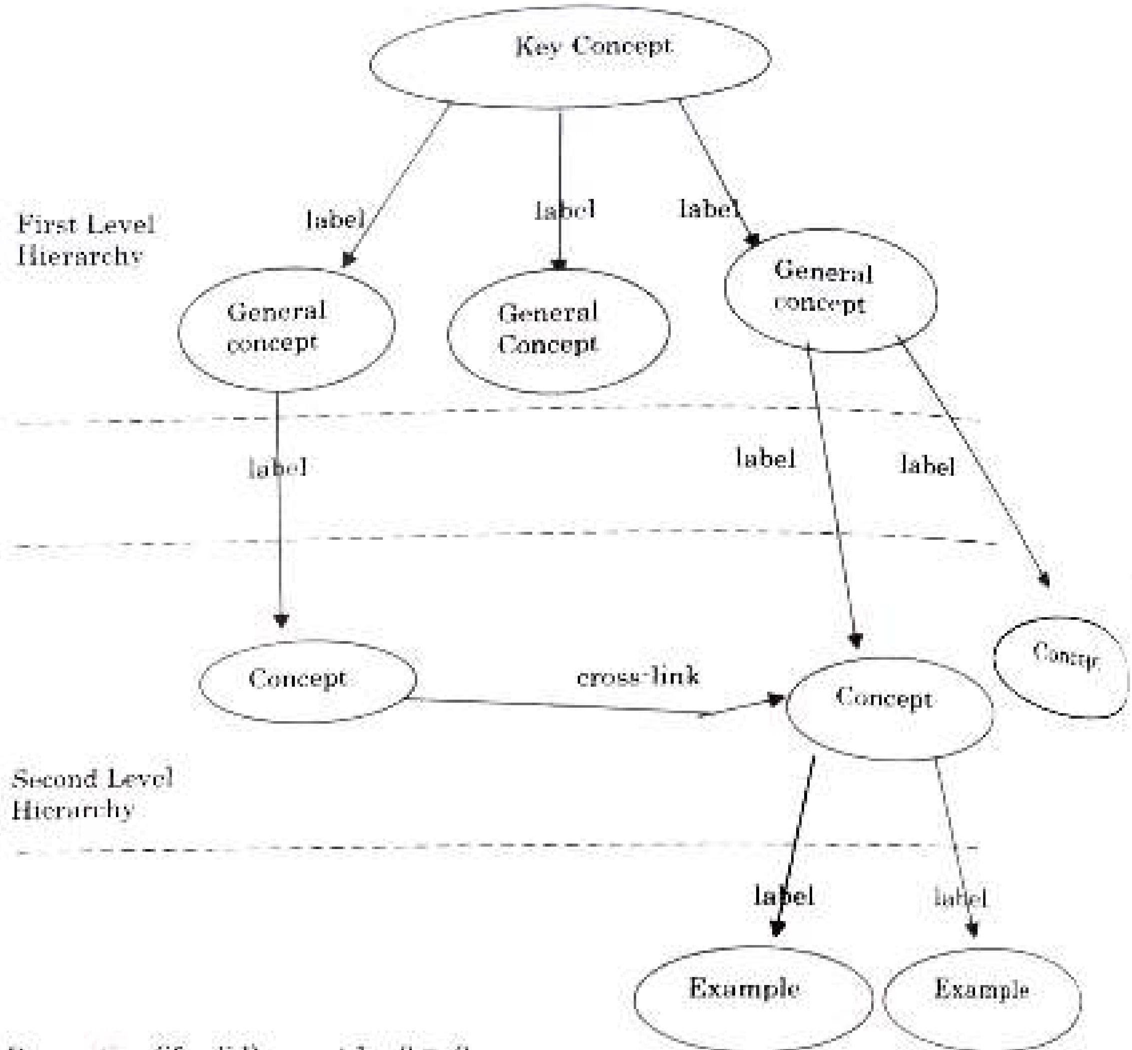


Figure 2. Protocol for Relational Scoring Method
[Adapted from McClure, Sonak and Suen (1999)]



Proposition (if valid) score : 1 x 8 = 8
Hierarchies (if valid) score : 5 x 2 = 10
Crosslink (if valid) score : 2 x 1 = 2
Example (if valid) score : 1 x 2 = 2
....
Total score 22

Figure 3. Instruction for Structure Scoring Method [Adapted from McClure, Sonak and Suen (1999)]

Figure 3 illustrates **the instruction** for the **structural scoring** used in this study. The structural scoring was adapted from the method proposed by Novak and Gowin (1984) and was tested for validity, reliability and logical practicability by McClure, Sonak and Suen (1999). This method, in addition to awarding points for identifying correct propositions, also considers the higher-level structure within the concept maps. Points are awarded based on the number of hierarchical levels and cross-links identified in the maps. Hierarchies are defined as branching structures that show superordinate-subordinate categorical relationship among concepts. Cross-links are relationship identified between concepts located in the different branches.

Total scores of the concept maps were derived from both relational and structural scores using a 50%-50% weight ratio. Thus, total concept map scores were computed using the formula: (relational score)(.50) + (structural score) (.50) = Total Score or (Relational Score + Structural Score)/ 2 = Total Score.

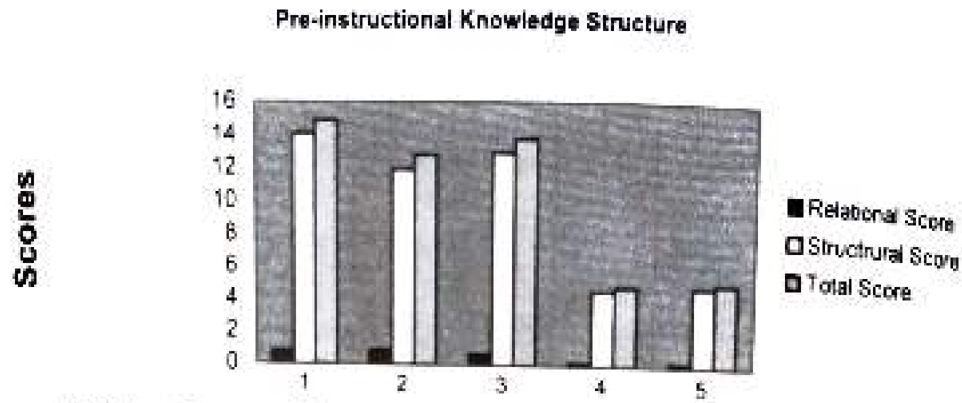
Statistical Tool Used

Statistical application such as mean and standard deviation, paired T-test and kendall's-Tau Coefficient were utilized to interpret relationship of biology teacher's representation of content knowledge and student's conceptual understanding.

Results and Discussions

Students' Pre-instructional Conceptual Knowledge Structure

Total mean scores of pre-instructional concept maps of the five topics is shown in Figure 4, which shows the complexity of the prior knowledge structure of high school biology students on the five topics chosen for this study. It is apparent in the figure that, among the topics covered, photosynthesis has the highest scores, followed by human reproductive system. The two lowest mean scores of the concept maps were on Mendelian genetics and non- Mendelian genetics.



	1	2	3	4	5
Relational Score	0.8	0.9	0.7	0.24	0.23
Structrural Score	14.09	11.9	12.95	4.635	4.87
Total Score	14.89	12.8	13.8	4.875	5.1

Topic

Figure 4. Pre-instructional Concept Map Scores of Student-respondents in the Five Biology Topics. (Legend : 1 = Photosynthesis; 2 = Cellular Respiration; 3 = Human Reproductive System; 4 = Mendelian Genetics;5 =Non-Mendelian Genetics)

The data suggest that there is a trend in terms of scores of students' prior knowledge. The trend is as follows: Photosynthesis > Human Reproductive System > Cellular Respiration > Non-Mendelian Genetics > Mendelian Genetics. This result is logical since photosynthesis and human reproductive system are already being taught in elementary grades while cellular respiration and genetics are newly introduced topics in high school. This observation also conforms to that of other authors. For example, Galili *et al.* (1993) states that students come into their classes with previously developed ideas and ways of thinking about certain phenomena, which are acquired, from formal and informal education. This contention has been documented in many studies using a wide range of domain (Galili *et al.*, 1993; Driver *et al.*, 1985; Pfund and Duit, 1988).

Another observation is that relational scores show that the concept maps of photosynthesis and human reproductive system have more integrated concepts as compared to those of cellular respiration and genetics. However, the relationship between a general concept (1st Level Hierarchy) and the corresponding concept (2nd Level Hierarchy) may not necessarily reflect the relationship between the general concept (1st Level Hierarchy) and the key concept. The data suggests that, at the start of the lesson, the students' knowledge structure is generally too simple or the ideas are not properly organized which is what Pearsal *et al.* (1996) calls 'weak restructuring'. The ideas are incoherent, not integrated and very inadequate.

Students' Conceptual Knowledge Structure: Pre- and Post- instruction

As mentioned, teachers' knowledge plays a vital role in restructuring students' ideas. The succeeding presentations discuss if the teachers were able to achieve their objectives in the transformation of students' knowledge structure.

Table 1 presents the change in students' knowledge structure based on the percent increase of concept map scores from pretest to posttest. Percent increase was calculated using the formula:

$$1)\ \%\ \text{Increase} = \frac{\text{Difference}}{\text{Pre-concept Map score}} \times 100\ \%$$

Based on cursory examination of the data from the table, the two lowest increases are in photosynthesis and human reproductive system. It can be noted, however, that both pretest and posttest scores in these two areas are high compared to genetics (Mendelian and non-Mendelian genetics).

Table 1. Change In Students' Knowledge Structure Based On Percent Increase Of Concept Map Scores From Pretest To Posttest

Topic	N	Instruction		Difference	Percent Increase
		PRE	POST		
Photosynthesis	208	14.89	16	1.11	7.45
***Cellular** Respiration*	205	12.80	16.335	3.53	27.62
***Human Reproductive** System*	198	13.65	16.6	3.05	21.61
Mendelian Genetics	191	4.875	11.61	6.74	138.2
Non-Mendelian Genetics	191	5.10	10.65	5.55	109.82

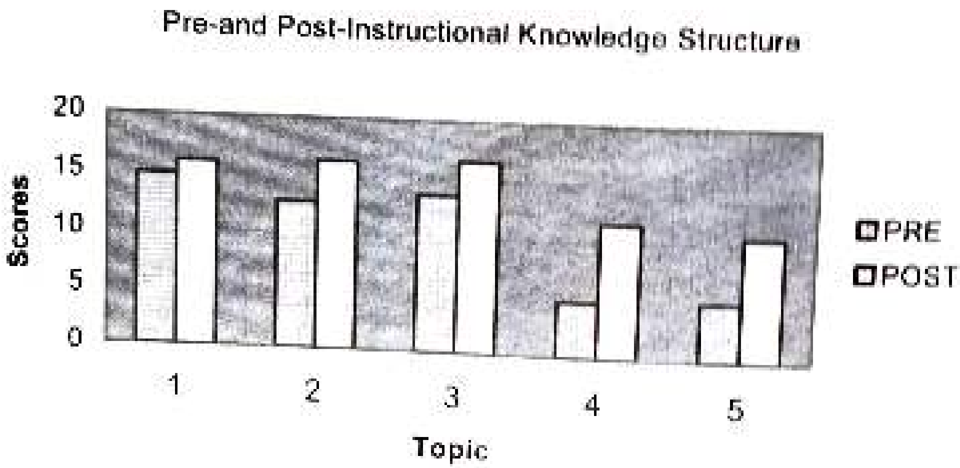


Figure 5. Comparison of Total Concept Map Scores of High School Biology Students in Pre- and Post-Instruction in Five Topics. (**Legend**:1 = Photosynthesis; 2 = Cellular Respiration; 3 = Human Reproductive System; 4=Mendelian Genetics; 5= Non-Mendelian Genetics)

Figure 5 compares the complexity of the knowledge structures of students based on the total mean scores in the pre- and post-instruction concept maps. The figure illustrates how much knowledge the teachers have successfully translated; the teachers have indeed changed the complexity of the students' knowledge structure. However, what is clearly noticeable in the figure is that photosynthesis, cellular respiration and human reproduction pre-instruction scores are already high compared to those of genetics; thus, after the intervention, only a small improvement only has been registered. Meaning, the students already knew most of the concepts. On the other hand, the students tend to accumulate more new content ideas on genetics, since these topics are new to them; thus, there is high increase in scores in these two topics. These results indicate that students tend to devote more attention to a new topic than to a more familiar one.

Statistically, Table 2 shows the paired t- test results in comparing the concept map mean scores of students before and after the teachers' representation of the content knowledge in the topics under study. As can be gleaned in the table, only the topics on photosynthesis and human reproduction show no significant difference between the pre- and post-instruction mean concept map scores. As explained earlier, this is due to the high pre-instruction scores. Likewise, it is observed in the SD's of the post-instruction scores that there is an increase in variability after the teachers' representation of content knowledge. Meaning, the students receive the teachers' representation differently. Most probably, high achievers tend to improve their conceptual understanding better than low achievers as a result of the teachers' representation of content knowledge.

This finding suggests that even the of variability of scores is affected by the teacher's representation of content knowledge. Highest SD value is observed in the topic photosynthesis.

Table 2. Paired t-test Analysis of the Five Topics

TOPICS		Mean	SD	Computed t-value*
Photosynthesis	Pre	14.89	4.313	
	Post	16.00	13.92	.889
Cellular Respiration	Pre	12.80	3.07	
	Post	16.34	3.87	-4.172*
Human Reproductive System	Pre	13.65	2.17	
	Post	16.6	7.59	-1.9
Mendelian Genetics	Pre	4.88	1.99	
	Post	11.61	6.27	-4.59*
Non-Mendelian Genetics	Pre	5.10	.976	
	Post	10.65	5.81	-4.69*

*Using SPSS significant @ α = .05

Thus, the results indicate that teachers' representation of content knowledge does affect individual students' conceptual understanding by increasing complexity of their knowledge structure as well as the class' spread of scores.

Relationship of Teachers' Representation of Content Knowledge Structure and Students' conceptual Understanding

Relationship in this study refers to the matching of the teachers' content knowledge and the students' conceptual understanding. The bases of this matching are the teachers' ranking of concept map scores in the same topic with the ranking of their corresponding students' post-instruction concept map scores. Hence, if the ranking of the students' mean scores in each topic parallels that of their corresponding teachers' ranks in the same topic, then there is relationship between the two

Table 3. Teachers' Concept Map scores and Students' Post-instruction Concept Map scores in five topics

a. Teachers' Concept Map Scores

Topics	Teacher FTC	Teacher JTB	Teacher CTR	Teacher RTL	Teacher JTM	Teacher CTC
Photosynthesis	47	63	15.6	29.5	76.9	42
Cellular Respiration	39	72	18.5	65.5	59	24.5
Human Reproductive System	43.5	66	25	57	52	33
Mendelian Genetics	29	32	18.5	40	39.5	22
Non-Mendelian Genetics	27	59	14.5	24.5	58.5	18.5

b. Students' Post-instruction Concept Map Mean Scores

Topics	Students of Teacher FTC	Students of Teacher JTB	Students of Teacher CTR	Students of Teacher RTL	Students of Teacher JTM	Students of Teacher CTC
Photosynthesis	17.7	17.8	17.69	16.7	21.4	5.75
Cellular Respiration	17.25	20	13.8	13.5	21.88	13.6
Human Reproductive System	12.27	21.12	13.5	17.35	17.72	16.56
Mendelian Genetics	7.8	14.9	7.7	10.36	14.5	8.95
Non-Mendelian Genetics	8.95	14.9	7	8.55	13.6	7.8

Tables 3 a and b present the teachers' concept map scores and the corresponding students' post-instruction concept map mean scores in all five topics under study. The two tables are transformed into Table 4, which gives ranking of scores of the teachers and the corresponding students. By random examination, the congruence of ranks between teachers and their corresponding students (highlighted in table) is quite evident.

Table 4. Ranking of Concepts Map scores of Teachers with the corresponding Students in five topics

Topic	Concept Map scores Ranking of	FTC	JTB	CTR	RTL	JTM	CTC
Photosynthesis	Teachers' Ranks	3	2	6	5	1	4
	Students' Ranks	3	2	3	5	1	6
Cellular respiration	Teachers' Ranks	4	1	6	2	3	5
	Students' Ranks	3	2	4	6	1	5
Human Reproduction	Teachers' Ranks	4	1	6	2	3	5
	Students' Ranks	4	1	6	3	2	5
Mendelian Genetics	Teachers' Ranks	4	3	6	1	2	5
	Students' Ranks	5	1	6	3	2	4
Non-Mendelian Genetics	Teachers' Ranks	4	1	6	2	3	5
	Students' Ranks	3	1	6	4	2	5

Table 5. The Relationship between Teachers' Representation and Students' Conceptual understanding as determine by Kendall's Tau

Topic	Computed Values				Interpretation
	Agreement P	Inversion Q	Space S	Tau Γ	
Photosynthesis	11	3	8	.533	Moderate or substantial agreement
Cellular respiration	9	6	5	.333	Little or small agreement
Human Reproduction	11	1	10	.667*	Moderate or substantial to high agreement
Mendelian Genetics	12	4	7	.477	Moderate or substantial agreement
Non-Mendelian Genetics	13	2	11	.733*	Moderate or substantial to high agreement
All Topics	9	1	8	.80*	High Agreement

To statistically test said relationship, the researcher utilized the nonparametric Kendall's tau Coefficient of Agreement test. Table 5 shows the statistical analysis of agreement of teacher representation (based on their concept maps ranking scores) and students' conceptual understanding (based on their post-instruction concept maps ranking scores). Table 5 is actually the Kendall's-Tau coefficient of agreement results of each of the five topics and all the topics. The hypothesis tested at $\alpha = .05$ is that there is no significant relationship between the rankings of students' post instruction concept map scores (students' conceptual understanding). As shown in the interpretation of results in Table 5, results indicated that all the 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 topic tested, human reproduction and Non-Mendelian genetics are significantly correlated at $\alpha = .05$, the latter being the highest at .733. What is noteworthy is the fact that Barquilla's (2002) results shows that the teachers are least knowledgeable in genetics. It is highly probable, therefore, that they exerted extra effort to make their representation of genetics concepts interesting and challenging to the students that the latter understood the concepts clearly.

The results suggest that most of the topics (Photosynthesis, human reproductive system, Mendelian Genetics and non-Mendelian genetics) studied have moderate or substantial agreement between the two groups. Pooling all the topics, however, it is shown that there is a high agreement between the teacher's representation and students' conceptual understanding (Post-instruction concept maps scores), significant at $\alpha = .05$ ($P = .042$). Hence the results suggest that teachers' representation does influences students' conceptual understanding.

Conclusions

The general findings indicate that teachers' representations of content knowledge does affect individual students' conceptual understanding by increasing complexity of knowledge structure as well as the class' spread of scores. There is a high agreement between the two groups. The teacher representation and students' conceptual understanding (Post-instruction concepts maps scores) agreement value is $\Gamma = .80$ (all topics combined) significant at $\alpha = .05$. Hence, the results suggest that teachers' representation highly influence students' conceptual understanding.

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