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Evaluation of Chemistry Content Knowledge and Verbal Analogical Reasoning as Potential Predictors of Teachers' Quality of Chemistry Concept Analogies

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ABSTRACT

This study evaluated the possible relationship of Chemistry Content Knowledge and Verbal Analogical Reasoning to Teacher's Chemistry Concept analogies among 20 Public High School Science Teachers in Cebu, Philippines using validated questionnaires. Test for Chemistry Content Knowledge showed that teacher-respondents' scores has a mean of 34.90, indicating an approaching proficiency level of knowledge in Chemistry concepts with Chemical reactions and Atomic structure as the least and mastered topics, respectively in the test. A mean of 23.10 was a result for the test in Verbal Analogical reasoning, indicating a below-average analogical reasoning skills among teacher-respondents. These then implied the need to improve teacher-respondents Chemistry Content Knowledge and Verbal Analogical Reasoning skills. Moreover, analogies by the teacher-respondents on Chemistry concepts exhibited qualities of good analogies, although some qualities such as the use of functional similarities and discussing the deviation of the target and analog concept were not observed. It was also found out that there were no significant relationship among the variables, Chemistry Content Knowledge and Verbal Analogical Reasoning as indicated by the p-value of 0.360. Moreover, relationships between Chemistry Content Knowledge to Chemistry Concept Analogies and Verbal Analogical Reasoning Analogies to Chemistry Concept Analogies were also not significant as indicated by p-values 0.097 and -0.068, respectively. Hence, Levels of Chemistry Content Knowledge and Verbal Analogical Reasoning were not predictors of the quality of analogies employed by teachers in teaching Chemistry concepts. This study aimed to provide educational experts insights into these factors' underlying relationships and improve chemistry education quality by supporting teachers' understanding of Chemistry concepts and use of analogies. Moreover, results of this study filled the gap of understanding the relationship between Chemistry Content Knowledge and Analogical Reasoning to teachers' effective use of analogies in teaching Chemistry concepts.

Keywords: *Analogies; Content Knowledge; Verbal Analogical Reasoning*

INTRODUCTION

Chemistry is composed of complex and abstract concepts (National Academies of Sciences, Engineering, and Medicine, 2016), which cause difficulty in understanding (Orgill & Bodner, 2004). This characteristic of Chemistry leads to problems with students' learning in Chemistry education. Consequently, it attributes to the result in students developing negative perceptions towards Chemistry (Mahdi 2014). Mahdi (2014) found out that students find Chemistry challenging and difficult to understand in his study in Saudi Arabia. The same result is found by Magwilang (2020) in her research in the Philippines, wherein students regard it as unrelated to the world they live in. Problems in students developing misconceptions about Chemistry are prevalent worldwide (Akaygun et al., 2018).

With these problems, teachers use analogies. Analogies provide an avenue for teachers to articulate ideas in a context familiar with the students and develop students' higher-order thinking (Akaygun et al., 2018). Various researches were conducted supporting this idea. In the research study conducted by Sarantopoulos & Tsaparlis (2004), they found out on their longitudinal study employing chemical analogies that students eventually developed positive attitudes towards Chemistry. It also enhanced students' conceptual changes when analogies are familiar and contextualized (Çalik et al., 2010). A study by Orgill & Bodner (2003) also found out that students mostly remembered instructor-made analogies and use them to visualize and recall information. Moreover, use of analogies has significant positive effect on the elimination of misconceptions to students (Ugur et al., 2012). In a study by Naseriazar et al. (2011), applying analogy-based learning in teaching chemical equilibrium students in the experimental group showed far greater achievement than students in the control group. Furthermore, the application of 5E model with an analogy approach increases students' conceptual understanding of chemical reactions (Supasorn & Promark, 2015).

Although analogies provide a possible solution to help students appreciate and understand Chemistry, it may result in misconceptions when misused. Students develop misconceptions towards Chemistry due to some factors such as familiarity of concepts being compared (Çalik et al., 2010), teachers not being able to show the differences of the ideas (Aubusson et al. 2009), and teacher-student difference in mapping analogies (Niebert & Gropengießer, 2014). Hence, mapping similarities across contexts require content knowledge and analogical reasoning skills.

Chemistry content knowledge is defined as one's mastery of scientific concepts, principles, and theories in chemistry. It is essential in dealing with the complexity of Chemistry concepts and performing complex tasks. Complex tasks in teaching Chemistry involve identifying misconceptions, presenting models, constructing tasks that will engage learners in the inquiry model, and explaining complex ideas connected to the core idea (Galiza et al., 2018). Content knowledge and teachers' understanding of Chemistry concepts are positively correlated (Ybañez et al., 2016).

An aspect of content knowledge is Pedagogical Content Knowledge. It blends content knowledge and pedagogy knowledge along with the application of pedagogical knowledge within a specific concept (Mishra & Koehler, 2006). It is acquiring the knowledge of both the how and what in teaching. As cited by Galiza et al. (2018) from two independent studies conducted by Kaya (2014) and Van Driel et al. (2002), it appears that Science Content Knowledge is rarely studied than Pedagogical Content Knowledge, although both are necessary for scientific understanding. Thus, an assessment of Content Knowledge is also essential for research.

Moreover, analogical reasoning is a cognitive skill inculcated in most of these 21st-century competencies (Richland & Simms, 2015) and can draw similar characteristics across contexts (Vendetti, Matlen, Richland & Bunge, 2015). According to Gentner (1983), it is recognizing and understanding the shared relationships of both ideas. Analogical reasoning is actively used in teaching as teachers employ various strategies such as analogies, metaphors, and models. These strategies are collectively considered analogies for comparing one object or situation to another require transferring details such as similarities and differences (Duit, 1991; Ugur et al., 2012). A study by Whitetaker et al. (2015) aims to determine whether the mechanisms by which analogical reasoning about semantic relations improve over age differences. Ages 6-18 years old individuals participated in this study. It was found out that semantic retrieval was positively correlated with age.

Hence, Chemistry Content knowledge is involved in knowledge acquisition while Analogical reasoning is for knowledge construction.

Understanding teachers' essential role in the teaching-learning process has provided research opportunities to look into factors that might affect how and what they teach. Moreover, with Chemistry Content knowledge an essential factor for a useful articulation of Chemistry concepts, and with teachers' use of analogies to express ideas, researchers may draw their relationships. However, existing literature regarding these relationships has been scarce, thus motivated the researcher to pursue this study and contribute to the existing body of knowledge on this area.

This study aimed to determine the relationship between Chemistry Content Knowledge and Verbal analogical reasoning to the quality of Chemistry concept analogies of public-school science teachers of the Department of Education Cebu Province. The results obtained determined the: (1) level of Chemistry Content Knowledge; (2) most and least mastered topics in Chemistry Content Knowledge test; (3) level of Verbal Analogical Reasoning; (4) quality of Chemistry Concept Analogies; (5) correlation between Teachers' Chemistry Content Knowledge and their Verbal Analogical reasoning; and (6) correlation between the teachers' quality of Chemistry Concept Analogies to Chemistry Content Knowledge and Verbal Analogical Reasoning.

Results are aimed to provide educational experts insights into these factors' underlying relationships and improve chemistry education quality by supporting teachers' understanding of Chemistry concepts and use of analogies. Moreover, teachers could be made aware of the importance of knowing the strengths and weaknesses of analogies and how a deeper understanding of the Chemistry concepts influences it.

METHODS

Research Design, Locale and Participants. The study is a descriptive-correlational study wherein it employs both descriptive and correlational analysis of data. For descriptive analysis of data, quantitative data gathered is analyzed and compared to a set of qualitative descriptors to provide the extent of the measured values within each variable. Moreover, the correlational analysis determined relationships, which may occur between and among the variables. This was conducted in ten National High Schools in two towns located in Cebu's southeast region. The determination of these towns is randomly done from seven towns in the Second congressional district of Cebu Province. Twenty (20) randomly selected public secondary school teachers from two towns in the southern part of Cebu were collected. Teachers considered in the study taught Chemistry for a minimum of one year. Among these respondents, twelve (12) were BSEd Physical Sciences, two (2) BSEd General Science, two (2) BSEd Mathematics, two (2) BS Physics, one (1) BSEd TLE and one (1) BSEd Biological Sciences.

Research Instruments. Three (3) instruments were used in this study. Among these instruments, 2 were adopted and 1 was researcher-made which have measured the different variables essential in answering the research problems. Content Knowledge Test with a reported Cronbach alpha of 0.77 from a study conducted by Mongcal et al. (2017) was adopted to measure Teachers' level of knowledge in Chemistry. The scores of each teacher-respondent was interpreted by the following standards: 44-49= advanced; 38-43= proficient; 32-37= approaching proficiency; 26-31= developing; 30 and below= beginning. Moreover, standardized Verbal Analogy Test from a study conducted by Turney et al. (2003) was also adopted which measured the teacher's level of analogical reasoning. This test consists of 60 multiple choice verbal analogies in the form of word pairs a:b :: c:d which encompass general knowledge terms. Each item gives a word pair in the form of a:b and teacher-respondents will identify the most semantically-related word pair to the given pair among the given choices. This test measured how well teacher-respondents draw relationships between concepts. Scores were interpreted using the following standards: 55-60= superior; 49-54= above average; 43-48= average; 37-42= lower average; 36 and below= below average. Lastly, a researcher-made test was utilized to measure Teachers' level of Chemistry-concept analogy. It is a two-tier test consisting of a Likert-scale test (Part A), which stated the distinct characteristics of a "good" analogy in Teaching Chemistry according to Orgill & Bodner (2003) and assessed how frequent Teachers' employed and considered these factors. In the study, “good analogies” have these characteristics: various similarities, compare and contrast, familiar and contextualized, employs supplementary materials and are evaluated. Each response had a corresponding numerical value with never -1, rarely -2, sometimes-3, often-4, and always-5. An open-ended question served as Part B of the test, which had let the teacher provide one analogy and described how they employed it in Chemistry Teaching under the different stages of implementation. Scoring was done through comparison of the analogies to a rubric. Two (2) experts in Chemistry Education validated the instrument and pilot tested to 20 teacher-respondents. These experts are atleast Master’s degree graduate in Science Education or Chemistry Teaching and have published several papers in different national and international peer-reviewed journals. Moreover, they are serving as teaching mentors to undergraduate or graduate students in various universities. Reliability of the tool showed a Cronbach alpha of 0.98 indicating that it is acceptable. Total scores of the teacher-respondents in both parts of the test were interpreted using the following standards: 66.1-83=Outstanding; 49.6-66= Very satisfactory; 33.1-49.5= Satisfactory; 16.6-33= Fair; 16.5 and below= Poor.

Data Gathering Procedure. Permission from the Department of Education Cebu Province Division superintendent, with the endorsements from the principal and district supervisor of the schools where the study was conducted were first secured. These permits were then received and sent to the different schools, which commenced the data gathering procedure. Informed consents were given to the teacher-respondents indicating the purpose, background of the study, benefits and risks, and voluntary participation. The different tests were answered through Google forms due to the ongoing COVID-19 pandemic. Each test had no time limit, and the respondents submitted their responses to each test a week after receiving the email containing the test questions. This flow was followed in answering the various tests: Chemistry-concept analogy Questionnaire, Chemistry Content Knowledge test, and Verbal analogy test. The validated researcher-made test on the Chemistry concept analogy questionnaire was answered first by the respondents. Then, the adopted Chemistry Content Knowledge test from a study by Mongcal et al. (2017) was answered. Lastly, the Verbal analogy test adopted from a study conducted by Turney et al. (2003) was answered. Retrieval of the teacher responses were gathered a week after the test questions were sent. Furthermore, the procedure ended with a Focused Group Discussion conducted to the respondents through video conferencing to determine their feedback and views regarding the tests.

Data Analysis. Data were analyzed using: (1) mean and standard deviation, with corresponding qualitative descriptions to determine the level of each variables and; (2) Pearson product moment of correlation to draw out the relationship among these variables. Moreover, these results were compared to existing studies to establish the reliability of results. And lastly, thematic analysis was employed to identify recurring themes in the teacher-respondents’ responses on the interview and provided analogies.

RESULTS AND DISCUSSION

The profile of the twenty (20) teacher-respondents (Table 1) showed that 18 out 20 or 90% were female with varied years of teaching experiences but majority have taught Chemistry concepts for 2 years or more. Twelve out of 20 or 60% obtained baccalaureate degrees in BSEd Physical Science and same number are currently attending graduate studies across various fields such as Science Education, Physics Teaching, and Chemistry Teaching.

Table 1. Teacher-Respondents' Profile

Respondent No.	Gender (M/F)	No. of Years Teaching	Baccalaureate Degree	Attending Graduate studies (Yes/No) *If Yes, specify what degree
1	F	3	BSEd Mathematics	MAEd Mathematics
2	F	4	BSEd Biological Sciences	No
3	F	30	BSEd Mathematics	Master of Education in Biology
4	F	3	BSEd General Science	No
5	F	2	BSEd Physical Sciences	MAEd Science Education
6	F	1	BSEd Physical Sciences	No
7	F	5	BSEd General Sciences	MAEd Science Education
8	F	3	BSEd TLE	MAEd Science Education
9	F	1	BSEd Physical Sciences	No
10	F	2	BSEd Physical Sciences	MAEd Science Education
11	F	2	BSEd Physical Sciences	Master of Education in Physics
12	M	2	BSEd Physical Sciences	No
13	F	8	BS Physics	MAEd Science Education
14	F	8	BS Physics	MAEd Science Education
15	F	1	BSEd Physical Sciences	MAEd Science Education
16	F	3	BSEd Physical Sciences	No
17	M	3	BSEd Physical Sciences	Master of Education in Physics
18	M	2	BSEd Physical Sciences	No
19	F	2	BSEd Physical Sciences	Master of Education in Physics
20	F	1	BSEd Physical Sciences	No

Level of Chemistry Content Knowledge of the Teacher-Respondents. The test scores for the Chemistry Content Knowledge of the twenty (20) teacher-respondents with 49 as the highest possible score (Table 2) showed that the highest score was 45 by Respondent 19, who graduated with a Bachelor of Secondary Education degree major in Physical Sciences (see Table 1). Moreover, the lowest score was 10 by Respondent 1, who graduated with a Bachelor of Secondary Education degree specializing in Mathematics.

Table 2. Teacher-Respondents' Chemistry Content Knowledge Test Scores

Respondent No.	Chemistry Content Knowledge (49)
1	10
2	23
3	38
4	37
5	33
6	39

Respondent No.	Chemistry Content Knowledge (49)
7	35
8	41
9	45
10	39
11	37
12	30
13	42
14	38
15	38
16	31
17	14
18	39
19	45
20	44

Statistical analysis of the data determined the teacher-respondents' level of Chemistry Content Knowledge (Table 3) showed that the mean of the score 34.90 out of the highest possible score of 49, with a standard deviation of 9.47. The result indicated an Approaching Proficiency level of the teacher-respondents' content knowledge in Chemistry. This means that the teacher-respondents have sufficient knowledge of the different concepts in Chemistry. However, as observed in the test result, some teacher-respondents exhibited a limited understanding of these concepts while most showed complete understanding. Thus, in general, teachers possess essential knowledge for the effective articulation of Chemistry concepts. This is in contrast to the results of the study conducted by Galiza et al. (2018) and Mongcal et al. (2017), where both measured low levels of content knowledge among teacher-respondents.

Table 3. Level of Chemistry Content Knowledge of the Science Teacher-Respondents

Variable	n	Mean	Standard Deviation	Qualitative Description	Correct Reponses (%)
Chemistry Concept Knowledge	20	34.90	9.47	Approaching proficiency	71. 22

The competency of the test questions was based on the Department of Education's K to 12 Science Curriculum Guide; hence the test can be answered by high school students. Analysis showed that when the overall mean is divided with the total number of items, the teacher-respondents correctly answered 71.22% of the test, which is 11.22% higher than the students' 60% standard passing score stipulated in DepEd Order No. 8 s. 2015: Policy Guidelines on Classroom Assessment for the K to12 Basic Education Program.

Although the percentage met the 60% passing score, the standards were for students and not for teachers. As indicated in the Philippine Professional Standards for Teachers (2017), a beginning teacher should have a strong understanding of the subject/s they are trained in, particularly, in the subject content knowledge. Hence, one must possess a mastery of the lesson to be taught. It is crucial since teacher's understanding of concepts will strongly influence the way they organize a lesson (De Jong et al., 2002). Moreover, a specified threshold on an exam determines mastery, often around 80% (Bloom, 19841971; Wiggins, 2013; Pearson & Flory, 2014). The teacher-respondents level of content knowledge is below the specified threshold; hence mastery is not evident.

Different factors have attributed to these results. One factor that might be seen is teacher-respondents' educational and professional background, precisely the specialization field. As observed in their responses, most teacher-respondents incorrectly answered or did not answer the open-ended questions requiring analysis (i.e., Why is salt solid at room temperature?), and problem-solving skills (i.e., If 3.15 g sodium reacts completely with 4.85 g chlorine, how many grams of sodium chloride would be produced?) although most of them are General Science and Physical Science graduates. This means that even teachers with chemistry backgrounds had insufficient mastery of the chemistry content, which corroborated with the findings of Coll and Taylor (2010), Lucille (2000) and Lin et al., (2000).

Furthermore, two of the respondents provided answers insignificant to the questions in the test. Respondent 1, a BSEd Biological Science graduate, responded with a "pass" on the item requiring to explain why salt is solid at room temperature. On the other hand, Respondent 2, a BSEd Mathematics graduate, answered "na" on the item about solving the product produced from a specified reaction. The "pass" response by Respondent 1 is interpreted as "I don't know what the answer is". Moreover the "na" response by Respondent 2 means "I don't have the knowledge to answer it." Hence, both responses indicate that the teacher-respondents did not know what and how to answer these questions. These indicate that the teacher-respondents might have experienced difficulties when undergraduate degrees or specializations were different from the subject taught (Fulgado and Ison, 2017). As gathered during the FGD, teacher-respondents forgot how to solve some topics, and some did not know what to do. The non-chemistry-specialized teacher-respondents (Mathematics, TLE, and Biological Sciences) remarked that great difficulty had been encountered in answering some of the topics in the open-ended questions, specifically topics involving solving for the amount of product produced since the concept is unfamiliar to them. Respondents mainly focused on the lessons in the grade level they were assigned to teach.

Conversely, the Physics major teacher-respondents generally find the test "bearable," and concepts are quite related to physical chemistry. Moreover, the chemistry-specialized teacher-respondents (Physical Sciences and General Sciences) considered the test as not complex and regarded that the test concentrated more on the "recall of information," which the respondents somehow failed to do. Generally, difficulty was brought about by the failure to recall prior knowledge on the concepts and the mismatch on the educational background of the teacher-respondents and the subject taught.

Another notable factor that might have contributed to the observation is the teaching experience of the teacher-respondents in teaching Chemistry. For instance, Respondent 3, a BA Mathematics graduate, got 38 items correctly, which is above the overall mean of 34.90. Hence, the teacher-respondents might have been familiar to the concepts in the test. These finding was in agreement with Kini & Podolsky (2016) who stated that repeated experience in teaching the same grade level or subject area improved the teachers' effectiveness to teach more rapidly than those whose experience is in varied grade levels or subjects. This improvement may be in the teacher's pedagogical skills or knowledge of the subject matter. Furthermore, it also substantiated this statement that repetitive teaching of the concepts provides opportunities to deepen teacher's understanding (Dean et al., 2012). Results of the FGD validated this observation since out of the 30 years teaching experience, Respondent 3 has been teaching Chemistry for more than ten (10) years. Moreover, the non-chemistry-specialized teacher-respondents' (Mathematics, TLE, and Biological Sciences) also remarked that teaching experiences on the concepts helped answer the test. Since the teacher-respondents were assigned to the same grade level for years, concepts became more familiar, and discussion of Chemistry concepts became a routine. Continuing Professional Development also provided more opportunities for them to learn. The same response from the Physics and Chemistry-specialized teacher-respondents was recorded. Moreover, prior knowledge was based on their baccalaureate-level lessons and experiences.

Generally, teacher-respondents' prior knowledge, continuing professional development, and teaching experiences were the identified factors that have helped answer the test.

Teacher-Respondents' Least and Most Mastered Topics in Chemistry. The percentage of correct answers of the teacher-respondents on the different concepts in Chemistry (Table 4) showed that the top three least mastered topics are Chemical Reactions, Metals, and Nonmetals and Solutions. The questions in Chemical Reactions required the teacher-respondents to solve the reaction yield from a given amount of reactants. It was observed that most teacher-respondents have not provided answers or incorrectly provided the amount of product that may yield from the reaction, which indicates that teacher-respondents have insufficient understanding of this concept. This is supported by the results of the FGD, where teacher-respondents remarked that they struggled with concepts in Chemistry that require problem-solving. This supports the statement by Gabel (1986) where problem-solving requires understanding and interpreting the language used in the problem, understanding the concepts embedded in the problem, and performing mathematical operations. With the stated processes involved in problem-solving, the teacher-respondents during the FGD added that they need to acquire in-depth learning of concepts and improve more in employing mathematical operations.

Table 4. Percentage of Correct Responses on Content Knowledge Test per Topic and Ranking of Least Mastered Topics in Chemistry

Topics	**% Correct Responses**	**Rank Of Least Mastered Topics**
Chemical Reactions	38.33	1
Metals & Non-Metals	56.67	2
Solutions	60.00	3
Gas Laws	68.33	4
Organic Compounds	71.25	5
Elements and Compounds	72.00	6
Biomolecules	72.50	7
Mole Concept	73.33	8
Chemical Bonding	75.00	9
Periodic Table of Elements	77.50	10
Particulate Nature of Matter	78.33	11
Acids & Bases	81.67	12
Substances and Mixtures	85.00	13
Atomic Structure	87.50	14
Overall Mean Percentage	**71.22**	

Another topic that the teacher-respondents showed less mastery was the properties of Metals and Nonmetals. Analysis of the answers revealed difficulty in delineating the physical and chemical properties of metals and nonmetals, resulting in incorrect responses. The FGD suggested that the concept was known but found it challenging to determine physical and chemical properties since these were not emphasized in their high school and undergraduate years. The concepts on Solutions were also less mastered by the teacher-respondents. The test involves analyzing concepts involving the saturation of solutions and their differences to that of compounds and elements at the atomic level. Responses showed that they have associated the characteristics of elements and compounds with that of solutions. Problems on saturation of the given solutions were wrongly answered resulting in incorrect inferences on the solutions' saturation. In general, the failure of the teacher-respondents to master these topics was brought about by their limited knowledge on the concept and the difficulty in employing problem-solving skills. These results supported the result of the study by Kind (2014), where teachers still have significant misconceptions towards Chemistry concepts.

On the other hand, the three most mastered topics were concepts on Acids and Bases, Substances and Mixtures, and Atomic Structure. For Acids and Bases, questions involved determining the properties and pH levels. Analysis of the FGD showed better understanding on the concepts since they have experienced laboratory activities on this concept in their secondary and tertiary years, making it easier for them to recall the concept. Laboratory activities enable learners to gain first-hand experience of the concept, thus effectively developing understanding and appreciation of the concepts by the students (Pareek, 2019). Another topic more mastered by the teacher-respondents was on Substances and Mixtures. This topic requires identifying the elements and compounds and their properties. The teacher-respondents found the concept easy to recall since it was discussed even as early as Grade school years. The most mastered topic is on Atomic Structure. It entails concepts such as atoms and molecules and subatomic particles such as protons, electrons, and neutrons. These concepts were learned in high school and were given as projects, hence, they are familiar with the topic. In general, the authentic experiences and prior knowledge of the concepts enabled the easy recall of information..

Level of Verbal Analogical Reasoning of the Teacher-Respondents. Verbal analogical reasoning requires drawing relationships between concepts. In this study, teacher-respondents skill in identifying semantically-related terms to the given word pairs were measured using the tool by Turney et al. (2003).

The test scores for the Verbal Analogical Reasoning of the twenty (20) teacher-respondents with 60 as the highest possible score (Table 5) showed that the highest score recorded was 46, and 3 was the lowest. This depicted a large range between the highest and the lowest score. In general, most of the teacher-respondents scored lower than 50% of the highest possible score for this test.

The results on the level of Verbal Analogical Reasoning (Table 6) showed that the scores have a mean of 23.10 with a standard deviation of 11.73. With this, it can be interpreted that the teacher-respondents have below-average verbal analogical reasoning. This means that they cannot effectively delineate the similarities and differences of the word pairs in the test to the given choices, resulting in incorrect associations. This finding agreed with the statement by Gentner & Forbus (2011) and Holyoak (2012) that the teacher-respondents struggled to draw relationships between ideas and map them to find a standard relational system.

Performance on verbal analogical reasoning tasks is influenced by the gradual increase of an individual's structured world knowledge (Goswami & Brown, 1990; Goswami, 1991, 2001). The FGD showed that the teachers were significantly focused on their subject matter, and vocabulary is limited to science-related terms. According to Richland et al. (2006), vocabulary deficiencies are sufficient to explain failures to solve analogies involving words/concepts. In the case of this study, verbal analogies were employed. Hence, the discipline-specific vocabulary of the teacher-respondents might have influenced the scores in the test for analogical reasoning. This is supported by the results of the FGD, where most teacher-respondents reported struggles in picking appropriate word-pairs for the given pair of words in the stem. Moreover, the respondents reported an average level of English vocabulary. Science-related terms were more suited for them. In general, the teachers had difficulty answering the test due to unimproved vocabulary, which led to a false association between word pairs.

Table 5. Teacher-Respondents' Verbal Analogical Reasoning Test Scores

Respondent No.	Verbal Analogical Reasoning (60)
1	12
2	18
3	26
4	27
5	34
6	22
7	14
8	10
9	38
10	27
11	25
12	29
13	18
14	6
15	3
16	12
17	21
18	33
19	46
20	41

Table 6. Level of Verbal Analogical Reasoning of the Science Teacher-Respondents

Variable	n	Mean	Standard deviation	Qualitative Description	% Correct Reponses
Verbal Analogical Reasoning	20	23.10	11.73	Below average	38.50

Quality of Chemistry Concept Analogies. Chemistry concept analogies refer to the analogies employed by teachers in teaching Chemistry concepts. In the study, a researcher-made tool quantified the quality of these analogies based on the following qualities of "good analogies" by which analogies should have various similarities, compare and contrast, familiar and contextualized, use supplementary materials, and evaluated. These qualities are based on the characteristics of "good" analogies identified by Orgill & Bodner (2004). The total scores of the teacher-respondents to the test in Chemistry concept analogies with 83 as the highest possible score (Table 7) showed that the highest score is 80 by respondent 20 and the lowest score is 58 by respondent 19. Generally, the teacher-respondents scored high on this test.

The quality of the analogies employed in their classes (Table 8) showed that the teacher-respondents' Chemistry Concept Analogies has a mean of 70.85 with a standard deviation of 7.00. This is interpreted as an outstanding level of Chemistry concept analogies of the teacher-respondents suggesting that the analogies adhere to the qualities of "good" analogies identified by the study of Orgill and Bodner (2004). These qualities of good analogies require the consideration of factors such as similarities and differences of concepts compared, familiarity and contextualization, use of supplementary materials, and evaluation. This supports the models of using analogies: Teaching-with-Analogies model (Glynn, 2004, 2007) and FAR Guide (Treagust et al., 1996), wherein different factors should be considered in employing analogies as an instructional method.

Table 7. Teacher-Respondents' Chemistry Concept Analogy Test Scores

Respondent No.	Chemistry-Concept Analogy (83)
1	68
2	72
3	78
4	61
5	65
6	71
7	80
8	75
9	79
10	68
11	78
12	76
13	76
14	61
15	69
16	73
17	68
18	61
19	58
20	80

Table 8. Quality of Teacher-Respondents' Chemistry Concept Analogies

Variable	n	Mean	Standard Deviation	Qualitative Description
Chemistry Concept Analogies	20	70.85	7.00	Outstanding

Table 9 shows the summary of responses of the teacher-respondents when asked to give an analogy employed in teaching Chemistry concepts. The following shows the analysis of the teacher-respondents analogies based on the different determinants of a "good analogy":

Good Analogies have various similarities. Similarities between the target and analog concepts could be in functions or structures. Analogies used should have functional-structural similarities. In this study, the teacher-respondents' analogies are extensively focused on structural relationships. Furthermore, in terms of the number of similarities between the analog and target concepts, 12 out of 20 provided analog concepts with more than five similarities with the target concepts. This suggests that the teacher-respondents were able to find analog concepts with high degree of similarities with that of the target concepts. This substantiated the statement by Gentner (1983) that the use of analogies considers recognizing the shared relationship of both ideas. The following analogies provided by the teacher-respondents substantiated this finding:

> **Respondent 8**: *"The structure of an atom is like a tiny solar system wherein the nucleus is found at the center just like the sun, which is surrounded by negatively charged particles - the electrons. The electrons are like the planets revolving around the sun through its orbit."*
>
> **Respondent 11**: *"I will let the students think about a ladder and then show them the structure of the DNA."*

Respondent 12: *"(I use the concept where) electrons are like satellites that revolve around the nucleus just as the moon, which is the natural satellite of the Earth, revolves around it."*

Good Analogies compare and contrast. Analogies employed in teaching should be elaborated on their similarities and differences. Results showed that all teachers used analogies to show similarities of the target and analog concept, but a majority did not explain the differences of the compared ideas. Precisely, this constitutes 18 out 20 respondents who did not indicate whether they will show the differences of the concepts compared to analogies. The result showed that the teacher-respondents only looked into the similarities between the target and analog concepts. When they were asked during the FGD if analogies employed are contrasted, the responses were *"No, since similarities of the concepts are given more emphasis than their differences."* Misconceptions may occur if the target and analog concepts are not contrasted (Orgill &Bodner, 2004). The following analogies provided by the teacher-respondents validated this finding:

Respondent 5: *"Each individual person is unique, just like an element having a unique property."*

Respondent 18: *"I will present pictures of car bodies and car tires to the class, then the students will determine how many car(s) can be made out of the available materials (CB and CT). Then, I will ask which material is completely used up and which material is in excess."*

Respondent 5 has drawn the similarities between the uniqueness of a person to learn the concept about elements. If not contrasted, students may develop the idea that an element may possess human characteristics. Furthermore, for Respondent 18, the development of misconception that products generated are in discrete quantities, like cars, may occur.

Good Analogies are familiar and contextualized. Analogies should be meaningful to students' experiences. Furthermore, analyses of the teacher-respondents' answers showed that familiarity to analog concepts is considered. Out of the 20 respondents, 14 stated that the students' prior knowledge considerations were done before using the analogy. Moreover, 11 out of 20 teacher-respondents contextualized the analogies employed to suit the students' experiences. This suggests that the teacher-respondents considered the students' prior knowledge of what analogies best suit the lesson. Hence, the use of standard and familiar concepts was extensively considered. The following analogies by the teacher- respondents supported these findings:

Respondent 4: *"(I will employ an analogy where)*
1 scoop of a certain ice cream- atom
2 scoops of the same ice cream - molecule
2 scoops of different flavored ice creams- compound"

Respondent 19: *"In group, students will measure the amount of water (heat) absorbed and released by the wet sponge using a graduated cylinder. To verify whether the reaction is endothermic (heat in the reactant is lower than its product) or exothermic (heat in the reactant is higher than its product), they will compare the amount of water absorbed or released by the sponge to the sponge's initial volume."*

However, one respondent employed an analogy about American football, which is not a familiar sport in the Philippines.

Table 9. Teacher-Respondents' Chemistry Concept Analogies

Respondent No.	*Lesson	Topic	Grade Level	Analog Concept (the concept familiar to students)	Target Concept (the lesson to be taught)	Provide a short description of the analogy you will employ.	Preparation (i.e. What factors will you consider before using the analogy?)	During Implementation (i.e. How will you employ the analogy in your class?)	I will use other materials to complement my analogy.	If yes, what is it?	After implementation (What do you do after utilizing the analogy?)
1	DME	States of Matter	7	Materials (i.e. chairs, water, air)	The arrangement of molecules in each state of matter anf how it affect its shape and apearance.	Solid is to closely packed molecules as gas is to far away molecules.	I will consider student's prior knowledge	I will use it as an end game. Or maybe a motivational game for the new lesson. Or a refreshments.	YES	Realia	Use more analogies for the next lessons.
2	PT	Symbols of Elements	7	Abbreviating words	Symbols of Elements	Give the symbol of an element	prior knowledge of students	Show different words abbreviated and then compare it to Chemical Symbols	YES	Colored papers	Evaluate
3	DME	Saturated solution	7	Seesaw	Types of Saturations	The classroom is ready to be occupied by 45 students. As you know, we could probably fit more students in the classroom than this, however, the available chairs are good as is for 45 students only - this is the saturation point of relative availability of comfort and ease of occupying in the classroom Saturation defines an equilibrium condition, in other words, there is (or would be) equilibrium between solute, and undissolved solute. And in the given analogy, the classroom can accommodate 45 students. So, if there are 70 students in the class, it will become supersaturated. Some students will sit on the floor. In the other hand, if there are only 20 students, it will become unsaturated. There will be vacant chairs.	The level of comprehension of the students, the attentiveness of the students, the appropriateness	Use visual aids while explaining as much as possible, on point delivery of the analogy, using bodily actions of delivery such as personal appearance, movement, gestures, and eye contact to the students.	YES	Visual Aids	Getting some feedbacks from students to improve the utilizing of analogy
4	DME	Atom, Molecules, Compounds	7	Ice cream scoops/Eating Ice cream	Identifying atom, molecules and compounds	1 scoop of a certain ice cream- atom 2 scoops of the same ice cream - molecule 2 scoops of different flavored ice creams- compound	The relevance of the topic and analogy being used.	Give situational examples. Student A vs Student B vs Student C	YES	Pictures/ Diagrams	Evaluate if the students grasps the idea or concept of the topic and the analogy being used.
5	DME	Elements and Compounds	7	Humans	Element	Each individual person is unique just like an element having a unique property.	environment	ask one student	No		students will make a refelction paper
6	DME	Acids and Bases reaction	7	American Football game (i.e. quarterbacks)	Acid-Base Reactions	The quarterback may be found in one of two "states": either holding onto the ball, immediately after the snap from the center , or without the ball, after successfully delivering a hand-off or pass. Similarly, acids may be found in either the protonated, acidic form (HB), or the deprotonated, conjugate base form (B). A good quarterback delivers the ball efficiently, by hand-off or pass. He (or she) gets rid of the ball, just as a strong acid gets rid of (donates) a proton. At the end of a play, nearly 100% of excellent quarterbacks will have delivered the ball. On the other hand, a bad quarterback delivers the ball inefficiently; he (or she) is indecisive and tends to hold onto the ball, just as a weak acid does not readily donate its proton. At the end of a play, far fewer than 100% of bad quarterbacks will have delivered the ball—perhaps only 1% (really bad!) or 10% (just plain bad).	In this analogy we liken an acid, which is a proton donor, to a quarterback: The quarterback is a football "donor", whose job is to deliver the ball by either passing it to a receiver or handing it off to a running back.	Through engagement activity or play game applying the concept of the process happing n the chemical reaction	No		Make it as springboard for other related topics
7	PT	Using the Periodic Table	8	Periodic Table	How to use the Periodic table	The uses of the numbers found in the periodic table	Their prior knowledge about the periodic table	Introduce the terms describe in the periodic table	No		Assessment
8	PNM	Atomic Structure of Matter	8	The Structure of the Solar System	Structure of an atom	The structure of an atom is like a tiny solar system wherein the nucleus is found at the center just like the sun which is surrounded by negatively charged particles - the electrons. The electrons are like the planets revolving around the sun through its orbit. Pictures of the solar system and an atom will be posted on the board so that students can visualize things that are being said.	Student's prior knowledge about the solar system. Student's learning style (i.e visuals, auditory etc.)	A picture will be posted on the board (structure of the atom and the solar system). Have the learners observe the two pictures in a while and have them jot down notes on their observation. Call representatives and have them discuss their observations to the whole class. Gather students idea and revisit during discussion.	No		Revisit used analogy to check students' understanding
9	PNM	Phase Transformation	8	States of Matter	Forces of attraction between particles during phase transformation	Group of people staying very close to each other in an open cooler space and as the sun's heat become stronger each person will move farther apart.... group of people resembles solid and the movement of people the force and as it move farther resembles melting (liquid) and as the people totally dispersed and can not be seen the gas phase	Knowledge of students about the topic	Introduction of the topic	YES	Realia	Letting the student's explain the concept in their own words
10	SOA	Chemical Bonding	8	Ball and stick model	Covalent bonding	Ball and stick model. Using styrofoams.	The availability of materials.	I will use a styrofoam ball and a stick and form the bonds.	YES	Pictures of the actual bonds	Assess the students
11	BIO	DNA (Definition and Structure)	9	Ladder	Structure of DNA	I will let the students think about a ladder and then show them the structure of the DNA	I will think of a familiar concept for them to grasp the topic easily	By showing visual aids and giving activities that will lead to the understanding of the unfamiliar concept	YES	3D Models and manipulatives	Elaborate
12	AS	Rutherford model of the atom	9	Revolution of satellites around planets	Electrons orbit the nuclues	Electrons are like satellites that revolve around the nucleus just as the moon which is the natural satellite of the Earth revolves around it.	Familiarity of the analogy, difficulty of the lesson	presenting simultaneously the analogy and the target lesson while explaining how these two have in common.	YES	Video clips	evaluate it whether it is effective or not
13	AS	Electronic Structure of Matter	9	Structure of an atom	Motion of the elctron around the nucleus	Solar system	The knowledge about the solar system	Comparison between the 2 concepts	YES	Video clip	Evaluation/Asessment
14	VCC	Hydrocarbons (Consumer Chemistry)	9	Carbon's physical and chemical properties	The different carbon compounds	ball and stick model ball represents the elements, different standard colors for every element, stick represents the bond type and bond length , carbon ball can only accomodate 4 sticks, hydrogen only one ... and so on..	i wasnt able to teach it during face to face classes where i wouldve used 3d kits, but this school year,online, i tried to draw them by hand using drawing tablets, presented on screen, but they werent 3d enough so i just searched for 3d molecule builders and gifs online. factors to consider: how close it is to the correct model , how will i explain or relate it, how concrete/how abstract	presented my drawing on screen, drawing real time so they can see how i did it, provide explanations, like why carbon can take 4 sticks etc.., point out that these are models,show actual em scans of molecules	YES	Video clip	Give examples, ask students to look up their own examples or build own hydrocarbon chains
15	CB	Chemical compound	9	Ion,atomic no.	Chemical,bonding	Present chemical,bonding	Knowledge of students	Explain how chemical bonding works	YES	Illustrations	Explain,ellaborate
16	GL	Charles' Law	10	Hot Air balloon	Temperature-volume relationship	Inquiry-Based Question: How does hot air balloon works?	The prior knowledge of the student.	I will employ it through an inquiry based question so that they will think first how it works.	No		I'll evaluate if the students got the analogy right
17	CR	Stoichiometry	11	Cars	Determining Limiting Reactant in a chemical reaction	I will present pictures of car bodies and car tires to the class, then the students will determine how many car can be made out of the available materials (CB and CT). Then I will ask which material is completely used up and which material is in excess.	Prior Knowledge of the students, Contextualization	Give practical and real world examples	YES	multimedia, pictures, realia	evaluating the students
18	CR	Effect of Temperature on Reaction Rates	11	Food preparation and storage/preservation	Relationship of temperature to reaction rates.	Reaction rates can be understood through collision frequency, collision energy and geometric orientation. These factors are also dependent and related to other factor like temperature. An increase to the temperature is an increase to the average velocity and to the average kinetic energy of the particles. Consequently, these particles collide more frequently and encounter other reactant particles. With enough increase in temperature, reactants gain the necessary activation energy to create a reaction. Through the concept mentioned above, cooking and storing of food in high temperature and low temperature respectively is made possible.	Check students' past experience on how they see their parents cook and preserve food. Check students' understanding about that experience.	Present them raw food pictures and let them choose one for their viand of the day and the other one for the next day's viand. Then ask the following questions: 1. How would you like to prepare and cook your viand? 2. What necessary steps and factors to consider in cooking your viand? 3. What should be done for the other viand in order to avoid spoilage? 4. What necessary steps and factors to consider in storing the other viand?	YES	Meat	Give necessary feedbacks about their understanding on the given scenarios. Explain to the class the details behind the factors affecting reaction rates and how this concept is applied in the kitchen or in food preparation and storage/preservation.
19	CR	Endothermic and Exothermic Reactions	11	Energy changes and breaking of bonds due to chemical reaction	Endothermic and Exotheric reactions	Endothermic and exothermic reactions are like sponge and water. The amount of water absorbed and released by the sponge is treated as the enthalpy (the quantity of energy transferred as heat during a chemical reaction). Endothermic reaction is like pouring water into a wet sponge. The sponge ends up with a greater water content (enthalpy) than before the reaction. Furthermore, the amount of water absorbed (say 100 mL) corresponds to the amount of heat. Exothermic reaction is like squeezing a wet sponge. The sponge ends up with a lower water content (enthalpy) than before the reaction. Furthermore, the amount of water released (say 100 mL) corresponds to the amount of heat.	1. Check students' prior knowledge on chemical reaction. Correct students' misconception as possible. 2. Inform students on how the analogy is related to the topic. Terms like "the amount of water" is equivalent to the heat absorbed or released by the reaction. Also, they will treat the sponge as where the chemical reaction took place.	In group, students will measure the amount of water (heat) absorbed and released by the wet sponge using a graduated cylinder. To verify whether the reaction is endothermic (heat in the reactant is lower than its product) or exothermic (heat in the reactant is higher than its product), they will compare the amount of water absorbed or released by the sponge to the sponge's initial volume.	YES	loofah and water; cotton and water; cloth and water	Evaluate whether the analogy implemented is effective or not by measuring students' test result.
20	AS	Subatomic particles	11	relationship	Subatomic particles and charges	Relate the different subatomic particles and their functions to social relationships	Individual differences	First, do some art of questioning	YES	Pictures	Assess the students response

*Based on the Curriculum Guide for JHS and SHS program of the Department of Education

Legend

PNM	Partcu
PT	Periodic Table of Elements
DME	Environment
CR	Chemical Reactions
AS	Atomic Structure
CB	Chemical Bonding

> **Respondent 6:** *"The quarterback may be found in one of two "states": either holding the ball, immediately after the snap from the center, or without the ball, after successfully delivering a hand-off or pass. Also, acids may be found in either the protonated, acidic form (HB), or the deprotonated, conjugate base form (B). A better quarterback will deliver the ball efficiently by hand-off or by pass. He gets rid of the ball, similarly as a strong acid gets rid of (donates) a proton. At the end of a play, nearly 100% of excellent quarterbacks will have delivered the ball. On the other hand, a bad quarterback delivers the ball inefficiently; he (or she) is indecisive and tends to hold onto the ball, just as a weak acid does not readily donate its proton. At the end of a play, far fewer than 100% of bad quarterbacks will have delivered the ball—perhaps only 1% (really bad!) or 10% (just plain bad)."*

Respondent 4 uses an analogy about scoops of ice cream with different flavors to differentiate atoms, molecules, compounds, and elements. Moreover, Respondent 19 employed an analogy of water absorption by a sponge to illustrate the concept of endothermic and exothermic reactions. These analog concepts are familiar to students since concepts can be easily observed in day-to-day activities. However, one response from Respondent 6 employed an analogy focused on American football. The sport is not popular in the Philippines, unlike basketball. During the FGD, the respondents were asked what made them choose the analogy. Respondent 6 responded, *"I have encountered it from an article explaining the concept of Acids and Bases and adopted it."* This means that, at times, teachers may use analogies without considering students' prior knowledge.

Good Analogies employ supplementary materials. Visuals appeal to the learners and contribute to the explanation of the analogy. Based on the teacher-respondents' Chemistry Concept Analogies, 19 out 20 teacher-respondents employed supplementary materials such as videos, pictures, simulations, and realia. Moreover, out of the 19 teacher-respondents who used supplementary materials in analogies, 12 stated that more than two types of visual materials were employed. This validated the results of Akaygun et al. (2018), where teachers were able to consider supplementary materials in providing analogies in teaching Chemistry. The following analogies by the teacher-respondents substantiated this finding:

> **Respondent 3:** *"(I will) use visual aids while explaining as much as possible, on-point delivery of the analogy, using bodily actions of delivery such as personal appearance, movement, gestures, and eye contact to the students."*

> **Respondent 10:** *"I will use a styrofoam ball and a stick and form the bonds."*

> **Respondent 18:** *"(I will) present them raw food pictures and let them choose one for their viand of the day and the other one for the next day's viand. Then ask the following questions:*
> 1. *How would you like to prepare and cook your viand?*
> 2. *What necessary steps and factors to consider in cooking your viand?*
> 3. *What should be done for the other viand in order to avoid spoilage?*
> 4. *What necessary steps and factors to consider in storing the other viand?"*

Respondent 3 stated that visual aids were employed to help understand the concept of Types of Saturations and explained that these visual aids mainly refer to pictures of substances in the particulate level. Respondent 10 used styrofoam balls and sticks to explain the concept of covalent bonding and chemical structures. For Respondent 18, pictures of food and probing skills were used to complement the analogy on the Effect of Temperature on the rate of chemical reactions. Hence, various supplementary materials were used to supplement the analogies. According to the results of the FGD, the reasons they use supplementary materials to aid the analogies are (1) to show the similarities in the structure of the analog and target concept, (2) to have a unified perception of the analog concept, and (3) to avoid misconceptions on the part of the students.

Good Analogies are evaluated. Analogies can cause misconceptions when improperly used. Hence, evaluation is necessary to judge if analogies employed improved the students' learning. Hence, the analysis of analogies showed that 14 out of 20 teacher-respondents evaluated the analogies employed by associating them to students' scores. The following analogies by the teacher-respondents validated this finding:

> **Respondent 3:** *"Getting some feedback from students to improve the utilization of analogy"*
>
> **Respondent 9:** *"Letting the students explain the concept in their own words."*
>
> **Respondent 14:** *"(I will let the students) give examples, ask students to look for their own examples or build own hydrocarbon chains."*
>
> **Respondent 20:** *"(I will) evaluate whether the analogy implemented is effective or not by measuring students' test result(s)."*

It can be seen that the Respondents 3 and 20 evaluated the analogies employed by associating them with the students' test scores. Moreover, Respondent 9 would let the students explain the concept based on their understanding, while Respondent 14 would ask the students to give examples. Analyses of the FGD showed that the teacher-respondents recognized the improper use of analogies may cause students to misinterpret the topics, hence, evaluation is essential.

In general, the teacher-respondents' Chemistry Concept Analogies have characteristics of good analogies; however, there is still a need to improve the analogies employed. These qualities involved choosing an analogy that will have both functional and structural similarities, elaborating the difference of the analog and target concepts to provide the limitation of the comparison between the analog and target concepts, use of familiar analog concepts to avoid misconceptions, supplementing the analogies with instructional materials to avoid disassociations, and constant evaluation to determine its effectiveness. According to Dagher (1995), analogies in teaching are not a function of whether an analogy is used. However, it is a function of *how it is employed*, *by whom*, *with whom*, and consequently, *how it is evaluated*.

Relationship between Teacher-Respondents' Level of Chemistry Content Knowledge and Analogical Reasoning. Table 10 presents the statistical analysis of the variables: Teacher-respondents' Levels of Chemistry Content Knowledge and Levels of Analogical Reasoning, using Pearson Product-Moment Correlation with a significance level of 0.05. The observed value of the correlation coefficient (r) is 0.360. This suggests a weak positive correlation. Hence, the two variables may be directly proportional, but this relationship is too weak and tends to be insignificant. Consequently, the calculated p-value is 0.119, which is greater than the significance level of 0.05. Thus, it failed to reject the null hypothesis, indicating no significant relationship between Levels of Chemistry Content Knowledge and Levels of Analogical Reasoning. It would mean that the variables are generally not associated with each other and a teacher who is good or poor in the content may have excellent or poor verbal analogical reasoning.

Table 10. Relationship Between Level of Chemistry Content Knowledge and Level of Analogical Reasoning of the Science Teacher-Respondents

Variables	n	Mean	Standard Deviation	Correct Responses (%)	Pearson Product Moment of Correlation Coefficient *r*	p-value
Chemistry concept knowledge	20	34.90	9.47	71.22	0.360	0.119^{ns}
Analogical reasoning	20	23.10	11.73	38.50	weak	

^{ns} not significant at $\alpha=0.05$

The result means that the Content Knowledge in Chemistry and Analogical Reasoning might be related, but both are significantly different. This result supported the study of Doolitle and Hicks (2003), where acquisition of knowledge (Chemistry Content Knowledge) is different from knowledge construction (Analogical Reasoning). Moreover, the result supported the study of Eskandar et al. (2013), where it was found out that employing analogies showed no significant effect on students' achievement in Chemistry. However, these results are in contrast to the study conducted by Wiley et al. (2018), where it was indicated that there is a relationship between the use of analogies and students' comprehension of content. The result may be attributed to the nature of Content Knowledge and Analogical Reasoning, which corroborated the findings of Gentner (1983), where Analogical Reasoning required prior knowledge to transfer explanatory structure from the source to the target domain. Hence, knowledge is transferred in order to create a new one. Consequently, knowledge is "chunked" into similar, retrievable categories with interconnected ideas (Ambrose et al., 2010). It employs knowledge construction wherein learning connects knowledge and concepts, constructing new meanings (NRC, 2000). Thus, both variables are dimensions of learning of the teacher-respondents, which the weak positive correlation between variables may exhibit, but significantly differ on how knowledge is processed and utilized observed insignificant relationship.

Content Knowledge involves learning by extracting, structuring, and organizing knowledge (Barett & Jones, 1989). It involves the process of absorbing and storing information in the memory (Anderson, 1982). Thus, knowledge is acquired and not constructed. These were also in agreement with the present findings. Furthermore, an analysis of the percentage of correct responses for each test showed that the accuracy level of the test answers of the teacher-respondents for Chemistry Content Knowledge and Analogical Reasoning is 71.22% and 38.50%, respectively. Hence, it can be interpreted that the teacher-respondents answered correctly more in the test for Chemistry Content Knowledge than Analogical Reasoning. As supported by the results of the FGD, they find the Chemistry content knowledge test a lot easier than the Analogical Reasoning test. Respondent 6 explained that *"it is easier since it just requires recall of information than analogical reasoning which requires careful association and drawing relationship across terms."* Thus, recall of information is easier than analyzing and synthesizing (Anderson & Krathwohl, 2001). This then suggests that the teacher-respondents should develop more skills in analyzing and synthesizing ideas..

Relationship between Chemistry Content Knowledge and Analogical Reasoning to Teacher-Respondents' Chemistry Concept Analogies. Table 11 presents the correlational analysis of Chemistry Content Knowledge and Verbal Analogical Reasoning to the Analogies employed by the teacher-respondents in teaching Chemistry concepts. Analysis of data resulted in an r-value of 0.097 and a p-value of 0.685. This suggests that there exists a positive relationship between Chemistry Content Knowledge and Chemistry concept analogies. However, this relationship is very weak to essentially non-linear relationship as indicated by the near-zero value of r.

Moreover, the magnitude of the p-value suggests that this failed to reject the null hypothesis, indicating that no significant relationship occurs between the variables. This means that a teacher with high or poor content knowledge may have outstanding or poor analogies employed in their classes. This supports the study conducted by Baumann (2020), where content knowledge does not relate to the quality of analogies, hence not sufficient means to create a good analogy. These also mean that there is more to creating good analogies than just subject comprehension and may imply an understanding of the dynamics of analogies' structural components. Furthermore, this result may be due to the analogies provided by the teacher-respondents wherein it did not fully encapsulate their depth on the content resulting in an essentially no linear relationship among variables. The teacher-respondents' analogies are significantly emphasized on the use of the analogy, and less emphasis is given on the consideration of the content in employing the analogy.

Table 11. Correlation of Chemistry concept analogy with Chemistry content knowledge and verbal analogical reasoning

Sample 1	Sample 2	n	Pearson *r*	p-value
Chemistry content knowledge	Chemistry concept analogy	20	0.097 Very weak	0.685 ^{ns}
Verbal analogical reasoning ability	Chemistry concept analogy	20	-0.068 Very weak	0.777 ^{ns}

^{ns} not significant at α=0.05

Chemistry Content Knowledge and Chemistry Concept Analogies. Consequently, as indicated by various researches (Akcay, 2016; Wiley et al., 2018, and Ugur et al., 2012), analogies improved the students' conceptual understanding; however, the result above showed that the opposite is not valid.

Verbal Analogical Reasoning and Chemistry Concept Analogies. Another relationship that should be looked into is between Verbal Analogical Reasoning and the analogies employed by the teacher-respondents in teaching Chemistry concepts. As shown in Table 6, analysis of the variables showed an r-value of -0.068 with a p-value of 0.0777. This could be interpreted as a negative correlation of the variables that may exist as depicted by the r-value; however, this relationship is very weak to essentially none, as indicated by the near-zero value of r. Moreover, the p-value suggests that this failed to reject the null hypothesis; thus, no significant relationship exists between variables. This means that the teachers with a high or low verbal analogical reasoning may have an outstanding or poor analogy employed in their classes. This is validated by the results of the study by Masterson et al. (1993), where the ability to learn a language affects the children's verbal analogical reasoning skills. The analogies employed in the test were not science-related concepts, which might have contributed to the difficulties in determining the words' meanings and their relationships. Furthermore, this result may be attributed to the verbal analogical reasoning that focused on the semantic relationships of the different concepts; however, this is just one factor in determining the quality of Chemistry concept analogies. Knowledge of pedagogical function in employing the analogy by the teacher-respondents was also considered to determine the quality of analogies employed. Hence, the analogies provided by teacher-respondents did not just look into the use of analogical reasoning in creating the analogies but also considered the knowledge on analogy implementation, which might suggest that this was measured more than the use of analogical reasoning resulting in the observed insignificant relationship between the variables.

In general, these results might suggest that the effect of the variables, Chemistry Content Knowledge and Analogical Reasoning, cannot effectively determine the quality of analogies employed by the teacher-respondents. This is supported by the study of Buchmann (1982), instead of looking at the variables as separate entities, the teacher-respondents' Pedagogical Content Knowledge, which is the knowledge on both content and instructional methods, might be looked into. Moreover, this supported the results of the study by Lucenario et al. (2016) which posited that enhancing the teachers' Pedagogical Content Knowledge showed significant mean scores on students' conceptual understanding and problem-solving skills.

CONCLUSIONS

Quantitative and qualitative data identified the content learning needs and the development of analogical reasoning skills among the teacher-respondents. Furthermore, analogies employed by the teacher-respondents indicated the need for employing both functional and structural analogies and drawing the differences between the analog and target concepts. Moreover, the relationship of each variable was not significant, suggesting that Chemistry Content Knowledge and Verbal Analogical Reasoning are not predictors of Teachers' quality of Chemistry Concept analogies. Hence, analogies are a function of *how it is employed*, *by whom*, *with whom*, and consequently, *how it is evaluated* (Dagher, 1995).

It is also recommended that the Department of Education provide opportunities to teachers' improvement of Content Knowledge by providing training in content, especially for those who do not specialize in the subject, and language strategies for teaching analogies. Furthermore, it is recommended for future studies to increase the sample size and analyze further analyses of the effect of Content Knowledge and Verbal Analogical Reasoning on the teacher-respondents' Analogies and focus also on the relationship between Teachers' Pedagogical Content Knowledge and Teacher-respondents' Analogies.

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