© 2016 IJSRST | Volume 2 | Issue 4 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Using Concept Mapping to Remediate Chemistry Teacher Trainees' Understanding of Chemical Phenomena – Before and After

Hanson R., Kwarteng T. A.

Faculty of Science Education, University of Education, Winneba, Ghana

ABSTRACT

Researchers have shown interest in how beginning chemistry teacher trainees can improve on their technological pedagogical content knowledge so as to be able to engage their students in concept-based and reflective activities. This is a task that trainees have to build up on their own by first mastering their content knowledge. This article focuses on 29 first year teacher trainees' understanding of chemical phenomena and how their understanding could be improved through concept mapping. An intervention was designed to enhance their basic conceptions upon which other concepts could be built. We analysed concept maps on linkages of periodic properties and how they affect chemical bonding. Their submissions were analysed based on three categories of conceptual understanding. The results showed that their levels of conception improved after the concept mapping intervention.

Keywords: Alternative Conceptions, Chemical Phenomena, Periodicity, Teacher Trainees.

I. INTRODUCTION

Chemistry is a discipline that enables students to develop acceptable ideas about the world in which they live. However, naïve, alternative, or wrong ideas, often called misconceptions could also be developed instead in a variety of ways. Wesson (2001) explained that when new information arrives in the cerebral cortex for analysis, the brain attempts to match each component with previously stored memory elements on the existing neural network and then files the new data by making connections to the old. If new information does not fit a learner's established pattern of thinking, they unconsciously or consciously refashion it to somehow fit their existing mental model. Thus, misconceptions are unknowingly created and reinforced upon faulty reasoning. Such misconceptions could be compounded when linkages are formed to yet other misconstrued or inaccurate ideas and further carried on from one generation to another- thus, creating a vicious cycle of misconceptions. The longer a misconception remains unchallenged, the more likely it is to become entrenched. Misconceptions are of considerable importance and cannot be ignored in the learning process since prior conceptions are foundations upon which knowledge is built (Pine, Messer & John, 2001).

Students' unscientific beliefs can influence them to have misconceptions in their learning processes. These beliefs can persist as lingering suspicions in their minds and hinder further learning. Students must therefore confront their own beliefs along with their associated paradoxes and limitations and then attempt to reconstruct the knowledge necessary to understand the scientific model being presented (Hanson, 2015). According to Gooding and Metz (2011), this process requires that teachers:

- Identify students' misconceptions
- Provide a forum for students to confront their misconceptions, and
- Help students reconstruct and internalize their knowledge, based on scientific models.

If meaningful learning does not occur, rote learning takes precedence. According to Clark, Nguyen and Sweller (2006) cognitive load could also lead to rote learning and subsequently, the formation of erroneous concepts. A consequence of rote learning is that new material is merely memorized, easily forgotten and not transferred (Bretz, 2001). Science educators must therefore improve their skills in such a way that students' misconceptions can be identified and addressed during teaching. Gooding and Metz (2011) stated that teachers should focus not just on repairing that which is broken, but also on preventive measures to help students avoid misconceptions from occurring.

Chemistry is one of the most important branches of science, but has been regarded as a difficult discipline by young students and some educators (Haider & Naqabi, 2008). The reasons for the said difficulties vary from the abstract nature of many chemical concepts to the difficulty level of the language of chemistry (Ozem, 2004). Besides the identified abstract nature, words from everyday language such as force, pressure and energy, with different meanings in the world of science, pose relational and interpretative problems for students during lessons (Taber, 2002). Such misconceptions constitute a major problem of concern to science educators, scientists, researchers, and students (Taber & Tan, 2011). Thus, this makes the identification of students' understandings and misconceptions an important area of research. Some of the conceptual areas in which most studies have been conducted have been on elements, compounds, and mixtures (Papageorgiou & Sakka, 2000), acids and bases (Boz, 2009), chemical stoichiometry (Haider & Al Naqabi, 2008) and chemical bonding (Ozmen, Demircioglu, & Demircioglu, 2009).

Although vernacular and factual misconceptions can often be easily corrected, even by the students themselves, it is not advised that teachers insist that learners dismiss preconceived notions and ingrained non-scientific beliefs without attending to the type or source of misconception. This must be done systematically and professionally. Recent research on students' conceptual misunderstandings of natural phenomena indicate that new concepts cannot be learned if alternative models that explain a phenomenon already exist in their minds (Hanson, Twumasi, & Antwi, 2015; Supasorn, 2015). Although scientists commonly view such erroneous models with disdain, they are often preferred by the learner because they seem more reasonable and perhaps more useful for the learner's purpose. Too often, teachers' zeal to get the right answers from students overshadows the efforts and implications behind students' own analysis to answers, especially if the student is wholly wrong. Incorrect answers are simply dismissed, instead of identifying the type of conception and seeing it as an opportunity for reflection, conceptual teaching and change (Gooding & Metz, 2011). Prior assessment of what students already know is thus a critical component of curriculum change and design which cannot be underestimated (Holme, et al., 2010; Singer, Nielsen, & Scweingruber, 2012).

Tools for students' knowledge structure

In order to assess what students know, which is a critical component of curriculum change, chemistry education researchers use a variety of diagnostic tools to uncover students' original, naïve, alternative, or prior conceptual understanding. A few of the diagnostic methods include think-aloud interviews (Cheung, 2009), concept inventories (Barbera, 2013; McClary & Bretz, 2012), conceptual text (Sevgi, Nurdane, Yezdan, Ayla, & Oktay, 2009) and concept mapping (Lopez, Shavelson, Nandagopal, Szu, & Penn, 2014; Greene, Lubin, & Walden, 2013). Two-tiered and four-tiered test items have also been used to identify students' own conceptions (Taber & Tan, 2011).This study will employ concept mapping to remediate and enhance teacher trainees' understanding about chemical phenomenon.

According to Nikita, Burrows and Suazette (2015), concept maps give teachers insight into students' 'whole' knowledge structures and allow them to pinpoint specific gaps in their mental structures. Studies conducted by Lopez, Shavelson, Nandagopal, Szu, and Penn (2014) and Szu, Nandagopal, Shavelson, Lopez, Penn, Scharberg and Hill (2011), have demonstrated that concept maps can be used to represent students' mental models or knowledge structures in organic chemistry. Specifically, their studies showed that concept map scores were correlated with scores on problem sets and final course grades. They also found that students' knowledge structures measured by concept maps were indicators of success in organic chemistry. Hanson, Twumasi and Antwi (2015), found that teacher trainees who could not provide appropriate links between science concepts had low assessment scores. They thus developed a concept test to scientifically assess their understanding of chemical phenomenon. Twelve (12) major misconceptions were identified in that study. They recommended that teachers assess the validity of their students' prior understanding of basic science concepts before teaching advanced topics that would require the application of those prior basic concepts. This suggests that educators of the sciences could improve teaching and learning of science by ensuring that misconceptions identified during teaching and evaluation exercises are addressed. In this current study, an in-depth study into trainees' conceptions about further work on chemical phenomena was carried out. This was because the level of the trainees' mastery of elementary concepts such as electronegativity, ionization energy, shielding effect, polarizability, effective nuclear charge and their linkages required for advanced studies on chemical phenomena was low.

Concept mapping is an ideal tool for assessing the depth and breadth of students' knowledge structures. It can indicate how students organize information into logical frameworks and allows teachers to visualise how students relate concepts to each other (Wheeldon & Faubert, 2009). Several studies have established the validity and utility of concept maps as an evaluation tool (Lopez et al., 2011).
Basically, concept maps are graphical tools used to organise and represent an individual's mental model or knowledge structure as they create relationships between a single concept and others in the same category in the form of propositions (Novak & Canas, 2006). It is a two-dimensional schema that illustrates mutual correlation or inter-conceptual relationships in graphics and help students to learn in a more meaningful way by relating old ideas to new ones in their minds. This kind of organisation prevents the formation of misconceptions and results in the identification of relationships. In this way, learning becomes more meaningful to students. Concept maps consist of three components – concept terms, linking arrows, and linking phrases. The linking arrows provide a directional relationship between two concepts while the linking phrases (words linking concepts) represent the specific relationships between at least two concepts. In chemistry studies, this could lead to the improvement of deductive, critical, analytical and reflective thinking skills, which are paramount to enhance gains in cognition.

Aim of Study

This study was a follow up to an earlier one on chemical phenomena (Hanson, Twumasi, & Antwi, 2015) in which teacher trainees' understanding about some basic chemical principles were assessed. A number of alternative conceptions about chemical phenomena were identified. The purpose of this current study was to use concept mapping to determine the trainees' conceptions after a treatment process related to bonding and applications of some periodic trends through concept mapping.

Research Questions

i. What conceptions do students have about the applications of periodic parameters?
ii. What improvements are evident in students' conceptions about chemical phenomena after using concept maps?
iii. How useful are concept tools as an innovative conceptual change strategy?

II. METHODS AND MATERIAL

Research Design

This was a case study which employed an intervention to solve an identified problem in three phases. Thus, concept mapping was used as a conceptual change tool to re-uncover the knowledge structure of teacher trainees before (pre-map) and after they had gone through a treatment period (post-map). Twenty one (21) chemistry undergraduate teacher trainees from the University of Education participated in the study. Pre- and post-intervention concept maps were constructed by trainees to enable the researchers identify new conceptions gained by them after the treatment period.

To begin with, the trainees were encouraged to use concept mapping or flow diagrams to illustrate how 14 terms on periodic properties (given to them) connected with each other to explain the concept of reactivity among group one elements. These terms were taken from their course text (Tro, 2010; McMurry, 2007). A 20-minute hands-on tutorial on how to construct concept maps was given to the trainees, prior to the construction of their mapping, so that they could all begin work with the innovative strategy from a common work level. They were encouraged to use extra terms which had not been supplied, if required. They were then given 60 minutes to complete their concept mapping, after which their constructed maps were assessed and scored by two trained chemistry senior lecturers of the Department of

Chemistry, University of Education, Winneba. Adjustments were made to the treatment designs (lessons) based on a review of the trainees' submissions. After the analysis of the pre-concept maps three lessons on periodicity were taught in which the researchers employed concept mapping. These treatment lessons became necessary as they were meant to address trainees' identified misconceptions from their pre-concept maps. After this treatment period, they were given an exercise akin to the pre-concept mapping assessment. These were also assessed using the same scoring mode as for the pre-concept maps.

Data Analysis

Concept Maps

The concept maps were scored by the trained researchers using the following four-level scale proposed by Lopez, Shavelson, Nandagopal, Szu and Penn (2014) and Szu (2011). They proposed the following scoring codes: 0 – incorrect or scientifically irrelevant, 1 – partially incorrect, 2 – correct but scientifically 'thin' (i.e. technically correct but answers are too general and/or vague), and 3 – scientifically correct and precisely stated. Each proposition in the concept map was therefore given a score between 0 and 3, according to the grading scale. The scores of pre- and post-map were compared and the percentages of trainees who scored between 0 – 1.4, 1.5 – 2.4 and 2.5 – 3.0 were grouped under descriptions of alternate conception (AC), partial conception (PC) and correct conception (CC) respectively. This was done to comparatively assess trainees' revised conceptual frameworks and gains after the treatment. According to Wang and Barrow (2013) identification of levels of conceptions for different group of students clarifies how they explain and reason when asked to work with targeted concepts. A typical concept map is presented as Appendix A.

III. RESULT AND DISCUSSION

The results of the pre- and post-maps have been presented as Table 1.

Table 1 : Level of trainees' performance in the pre-and post-concept mapping

CONCEPT	PRE-MAPS (%)			POST-MAPS (%)			Overall gains (Themes)		
	AC	PC	CC	AC	PC	CC	AC	PC	CC
Bond strength & temperature	51.3	32.1	16.6	20.1	48.0	31.9	0.64	0.23	0.18
Strength of hydrogen bond	25.5	51.0	23.5	21.0	35.5	43.5	0.06	0.32	0.26
Effect of nuclear charge on size	31.4	38.0	30.6	21.5	30.3	51.2	0.14	0.12	0.30
Electronegativity within groups	28.0	60.3	11.7	4.9	21.9	85.1	0.32	0.97	0.83
Strengths of bases within groups	20.2	51.4	28.4	15.0	36.4	48.6	0.07	0.31	0.28
Factors that affect lattice energy	53.5	26.3	20.2	31.5	36.0	32.5	0.47	0.13	0.15
Heat of hydration	42.1	30.5	27.4	34.0	33.2	32.8	0.14	0.04	0.07
Concept of electronegativity	36.7	55.6	7.7	15	37	48.0	0.34	0.42	0.44
Type of Bond	35.4	52.5	12.1	18	26.3	55.7	0.27	0.55	0.50

From Table 1, it is observed that moderate and high gains were made in the concepts about relating bong strength and temperature, the concept of electronegativity and how it affects elements within groups, and types of bonds. Not much gains were made in students' understanding about hydrogen bonding, the effect of nuclear charge on sizes of atoms, and heat of hydration. In all there were six (6) thematic conceptual gains and five (5) partial conceptual gains, out of a total of nine (9) themes.

Bond strength and temperature

After treatment, there was an increase in the percentage of trainees (16.6% to 31.9%) who were able to give conceptual explanation to bond strength and temperature. The percentage of trainees who demonstrated alternate and partial responses in the post-map was 20.1% and 48.0% respectively. They had difficulty in arranging types of bonds in terms of their strength and could not predict bonds that might have high boiling or melting point.

Strength of hydrogen bond

The percentage of trainees who made logical constructions increased from 23.5% to 43.5%. Most of the partial answers did not show linkages of hydrogen bonds to electronegative elements like nitrogen and oxygen. Such concept maps indicated that trainees had difficulty in identifying compounds which contained hydrogen bonds. Most of them perceived that all compounds containing hydrogen have hydrogen bond, such that a H_2 molecule was associated with hydrogen bonding.

The effect of nuclear charge on size

An increase in percentage of correct linkages rose from 30.6% to 51.2% due to trainees' ability to use more correct linking words. Majority were able to relate atomic size to nuclear effect. A few had difficulty in comparing ionic radii and so failed to identify and arrange isoelectronic species. Some also demonstrated alternative conceptions as they inked nuclear charge to the charge on atoms. All trainees correctly mapped that nuclear charge increased across the period.

Electronegativity within groups

The percentage of trainees who had correct propositions and links rose from 11.7% to 85.1% after treatment. This indicates that most of the trainees who had alternate and partial conceptions in their pre-maps reached correct conceptions through the treatment and were able to link correct propositions to explain the trend of electronegativity within groups. Few trainees with partial conceptions linked the trend of electronegativity to either nuclear charge or screening and shielding effect but not both.

Strengths of bases within groups

Only 48.6% constructed good maps about the trend of basicity of elements within a group and across a period with 36.4% and 15.0% showing partial and alternate conception respectively. The trainees had difficulties in comparing the basic strengths of elements in a period and within groups. Most of them intimated that basicity increased with electronegativity across the group and from bottom to the top within a group.

Factors that affect lattice energy

The percentage of trainees with correct conception increased marginally, from 31.2 to 32.5%. Results indicated that they had difficulties in stating and explaining factors that affect lattice energy. About 36% of trainees who were able to associate lattice energy to ionic charge and size of an ion could not give proper reasons for their decisions. The remaining 31.5% were those who had either wrong linkages or could not provide any at all.

Concept of electronegativity

The percentages of trainees who demonstrated alternate, partial and correct conceptions were about 15%, 37% and 48% respectively. It appears that majority of trainees could not reach full conception even after treatment. The concept-maps showed that they had difficulty on the concept of electronegativity which would require further treatment through other strategies. Trainees who gave alternate conceptions considered polarity as a type of bond but not an additional characteristic of bonding. Most of those who demonstrated partial conception could not give specific examples of polar and non-polar covalent bonds. A few however, were able to relate the essence of electronegativity values to bond polarity.

Type of bond

It was found that 55.7% of the trainees gained scientific understanding after treatment while 18% and 26.3% indicated alternative and partial conceptions respectively. Most of them could state, explain and give examples of types of bonds. For instance, a trainee linked ionic bond to *bonds that occur in opposite charges* but later indicated that the octet rule was the sole reason for bond formation. Metallic bonding was the least used term. Some major findings were that:

1. Analysis of constructed maps revealed that, trainees used a lot of invalid prepositions and unlinked conceptions in the pre-map than in the post-map.
2. Some trainees stuck to their old beliefs and wouldn't let go, but majority acquired scientific conceptions as the naïve conceptions disappeared from their post-maps
3. There was very little demonstration about knowledge of metallic bonding.
4. Participants were able to use more scientific terms and constructed more logical linkages with propositions given to them than in their pre-maps.
5. Most trainees who demonstrated partial conception lacked the knowledge to expand responses to phenomena.

The purpose of the study was for students to use concept mapping to express their conception of chemical phenomenon after they had gone through a 21 day treatment period. Results after treatment indicated that concept mapping was useful and revealed differences in conceptual frameworks between trainees with high and low levels of content knowledge, and pinpointed some key ideas lacking in their frameworks. There were increases in the percentages of trainees who gave correct responses in the post mapping. This happened because their content knowledge and skills for constructing concept maps were heightened during the treatment period. This enabled them to use more understandable concepts to form valid propositions. The use of concept maps enabled the researchers to evaluate trainees' own mental models and identified essential concepts that needed to be stressed to bridge learners' understandings to advanced levels (Nikita & Suazette, 2015). Findings from the study are consistent with that by Mustafa and Murset (2013) that concept mapping addresses different forms of learning and individual differences between students. The validity and utility of concept maps were verified in this study as intimated by (Lopez, Shavelson, Nandagopal, Szu, & Penn, 2014; Greene, Lubin, & Walden, 2013). There was however, an apparent lack of knowledge about metallic bonding which was quite strange and will require further remediation.

IV. CONCLUSION

The depth and breadth of trainees' knowledge structures were easy to diagnose through concept mapping. Findings showed the importance of using diagnostic tools, especially concept mapping, to enable trainees to relate current concept to explain chemical phenomenon. Nahum, Mamlok-Naaman and Taber (2010) confirm that learning about chemical bonding allows the learner to make predictions, and give explanations, about physical and chemical properties of substances. Science educators must ensure that misconceptions of students are addressed to enhance effective learning of science (Greene, Lubin, & Walden, 2013).

V. ACKNOWLEDGEMENT

The authors wish to acknowledge the immense contributions of trainees who participated in this study.

VI. REFERENCES

[1]. Barbera, J. (2013). A psychometric analysis of the chemical concepts inventory. *Journal of Chemical Education, 90*(5), 546-553.

[2]. Bretz, S. L. (2001). Novak's theory of education: Human constructivism and meaningful learning. *Journal of Chemical Education, 78*(8), 1107-1109.

[3]. Cheung, D. (2009). Using think-aloud protocols to investigate secondary school chemistry teachers' misconceptions about chemical equilibrium. *Chemical Education Research and Practice, 10*, 97-108.

[4]. Clark, R. C., Nguyen, F., & Sweller, J. (2006). *Efficiency in learning: Evidence-based guidelines to manage cognitive load.* San Francisco: Pfeiffer.

[5]. Gooding, J., & Metz, B. (2011). From misconceptions to conceptual change. *The Science Teacher*, 34-37.

[6]. Greene, B., Lubin, I., & Walden, S. (2013). Mapping changes in science teachers' content knowledge: Concept maps and authentic professional development. *International Journal of Science Education, 1*, 1-13.

[7]. Haider, A. H., & Al Naqabi, C. A. (2008). Emirati high school students' understandings of stoichiometry and the influence of metacognition

on their understanding. *Research in Science and Technological Education*, *26*(2), 215-237.

[8]. Hanson, R. (2015). Identifying students' alternative concepts in basic chemical bonding- a case study of teacher-trainees in the University of Education, Winneba. *International Journal of Innovative Research and Development*, *4*(1), 115-122.

[9]. Hanson, R., & Acquah, S. (2014). Enhancing conceptual understanding through the use of microchemistry equipment and collaborative activities. *Journal of Education and Practice*, *5*(12), 120-130.

[10]. Hanson, R., Twumasi, A. K., & Antwi, V. (2015). Undergraduate chemistry teacher trainees' understanding of chemical phenomena. *European Journal of Basic and Applied Sciences*, *2*(3), 8-14.

[11]. Holme, T., Bretz, S. L., Cooper, M., Lewis, J., Paek, P., Pienta, N., . . . Towns, M. (2010). Enhancing the role of assessment in curriculum reform in chemistry. *Chemical Education Research and Practice*, *11*(2), 92-97.

[12]. Lopez, E. J., Shavelson, R. J., Nandagopal, K., Szu, E., & Penn, J. (2014). Factors contributing to problem-solving performance in first semester organic chemistry. *Journal of Chemical Education*, *91*(7), 976-981.

[13]. McClary, L. M., & Bretz, S. L. (2012). Development and assessment of a diagnostic tool to identify organic chemistry students' alternative conceptions related to acid strength. *International Journal of Science Education*, *34*(15), 2317-2341.

[14]. McMurry, J. (2007). *Organic Chemistry*. Boston: Cengage Learning.

[15]. Mustafa, K., & Murset, C. (2013). Concept maps as a tool for meaningful learning and teaching in chemistry education. *International Journal on New Trends in Education and Their Implications*, *4*(4), 10-15.

[16]. Nahum, T., Mamlok-Naaman, R., Hofstein, A., & Taber, K. S. (2010). Teaching and learning the concept of chemical bonding. *Studies in Science Education*, *46*(2), 179-207.

[17]. Nikita, L. B., & Suazette, R. M. (2015). Using concept mapping to uncover students' knowledge structures of chemical bonding concepts. *Journal of Chemistry Education Research and Practice*, *16*, 53-66.

[18]. Novak, J. D., & Canas, A. J. (2006). *The theory underlying concept maps and how to construct and use them*. Florida: Florida Institute for Human and Machine Cognition.

[19]. Ozem, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bonding. *Journal of Science Education and Technology*, *13*(2), 23-29.

[20]. Ozmen, H., Demircioglu, H., & Demircioglu, G. (2009). The effects of conceptual change texts accompanied with animations on overcoming 11th grade students' alternative conceptions of chemical bonding. *Computers and Education*, *23*(3), 681-695.

[21]. Papageorgiou, G., & Sakka, D. (2000). Primary school teachers' views on fundamental chemical concepts. *Chemistry Education Research and Practice in Europe*, *1*(2), 237-247.

[22]. Pine, K., Messer, D., & John, K. (2001). Chidren's misconceptions in primary: A survey of teachers' views. *Research in Science & Technological Education*, *19*(1), 79-96.

[23]. Ruiz-Primo, M. A., Schultz, S. E., Li, M., & Shavelson, R. J. (2001). Comparison of the reliability and validity of scores from two concept mapping techniques. *Journal of Research in Science Teaching*, *38*(2), 260-278.

[24]. Sevgi, A., Nurdane, A., Yezdan, B., Ayla, C. D., & Oktay, B. (2009). The contribution of constructivist instruction accompanied by conceptual understanding of chemistry in the laboratory course. *Journal of Science Education and Technology*, *18*, 518-534.

[25]. Singer, S. R., Nielsen, N. R., & Scweingruber, H. A. (2012). *Discipline-based education research*. Kluwer: National Academic Press.

[26]. Supasorn, S. (2015). Grade 12 students' conceptual understanding and mental models of galvanic cells before and after learning by using small-scale experiments in conjunction wiyh a model kit. *Chemical Education Research and Practice*, *16*, 393-407.

[27]. Szu, E., Nandagopal, K., Shavelson, R. J., Lopez, E. J., Penn, J. H., Scharbeng, M., & Hill, G. W. (2011). Understanding academic performance in organic chemistry. *Journal of Chemical Education*, *88*(9), 1238-1242.

[28]. Taber, K. (2002). *Chemical misconceptions-Prevention, diagnosis and cure. Volume 1: Theoretical background.* London: Royal Society of Chemistry.

[29]. Taber, K. S., & Tan, K. C. (2011). The insidious nature of 'hard core' alternative conceptions: Implications for the constructivists research programme of patterns in high school students' and pre-service teachers' thinking about ionisation energy. *International Journal of Science Education*, *33*(2), 259-297.

[30]. Tro, N. J. (2010). *Principles of chemistry: A molecular approach.* New York: Prentice Hall.

[31]. Wang, C. Y., & Barrow. (2013). Exploring conceptual frameworks of models of atomic structures and periodic variations, chemical bonding, and molecular shape and polarity: A comparison of undergraduate general chemistry students with high and low levels of content knowledge. *Chemistry Education research and Practice*, 130-146.

[32]. Wesson, K. (2001). What recent brain research tells us about learning. *Independent School*, *61*(1), 58-69.

[33]. Wheeldon, J. P., & Faubert, J. (2009). Framing experience: Concept maps, mind maps, and data collection in quantitative research. *International Journal of Qualitative Methods*, *8*(3), 52-67.

Appendix A : Example of Concept Map on Periodic Trends