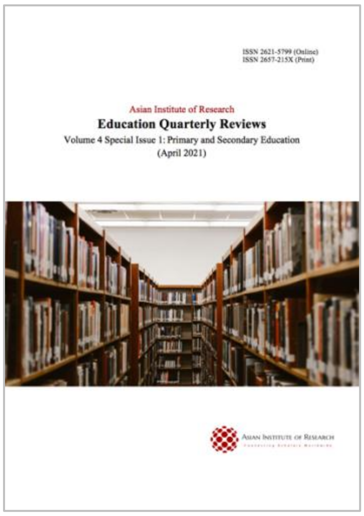

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Assessment of Awareness of Chemistry Concepts with Thesaurus Task: 9th Grade Vocational High School Students Sample

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Abstract
The study was conducted at a vocational high school in Ankara during the academic year of 2018-2019 based on the key concepts regarding the units in the chemistry curriculum for 9th grade. The purpose of the study was to investigate whether 9th grade students recognized the key concepts in chemistry units of first and second semester, and how correct their relevant definitions were. In the first unit, 9 students could determine a sufficient number of key concepts; however, in the proceeding units, the number decreased, and none of the students were able to recognize the correct concepts in the last unit. Another important finding of the study was that students included high-level concepts in their dictionaries even though they had difficulty in identifying the basic key concepts offered in the curriculum. It revealed that students attempted to explain unrecognized concepts through an unfamiliar terminology. Accordingly, it was inferred from the data obtained that students entered into chemistry with fundamental conceptual deficiencies. When concept-related definitions in student thesauruses were examined, it was revealed that the majority could make scientific explanations and choose their resources correctly; nonetheless, a small number of students could not make sufficient descriptions or used expressions far from scientific explanations. One of the important aspects of this study is that, teachers need to give the key concepts to students in detail first, and demonstrate in practice how to look up their explanations in the right resources. This constitutes the main scientific background of our study.

Keywords: Chemistry Education, Chemistry Concepts, 9th Grade, Key Concept, Glossary, Thesaurus

1. Introduction

By means of education and experience, people acquire the facts related to the world around them, and the necessary skills and knowledge to survive in the world. From this viewpoint, each education system is planned to increase the amount of knowledge in individuals. However; schooling, study, observation and experience progress differently for each individual because they form “concepts” as main elements of a specific piece of information with unique combinations of the known and unknown in their minds. A student, throughout his/her education process, passes through a series of knowledge levels and obtains a new conceptual understanding of the universe. While moving from an academic lesson to another, the balance of known and unknown concepts in student's mind changes gradually (Raud, Vodovozov & Lehta, 2012). Basic knowledge and skills targeted to be acquired by students under the guidance of teachers are offered within the curriculum framework, and it is based on providing in-discipline and interdisciplinary information flow (Raud & Vodovozov, 2012). Interdisciplinary approach is viewed as a way of bringing together different disciplines in a meaningful and practical manner so that students perceive knowledge and skills as a whole rather than discrete pieces. This approach is consistent with our natural way of thinking, which is holistic most of the time (Yıldırım, 1996). The situation requiring sensitivity in the process is the fact that the existence of unknown components in academic teachings prevents progress in learning (Raud, Vodovozov & Lehta, 2012). Therefore, it is regarded important that students improve their terminology in the relevant fields. For instance, in the education system, if terminology offered in the first semester courses is considered as tree roots, the concepts in the following semesters are tree branches and leaves (Raud & Vodovozov, 2012). If competence in a field subject is accepted as a communicative achievement, language development is essential. It is impossible to form the scientific background of a lesson without basic concepts. Competence in scientific field regarding student level is expressed by being able to recognize and explain concepts in the relevant lecture flow. Inadequate vocabulary in the field causes conceptual mistakes and misunderstandings. At this point, it is considered necessary that student's receptive and productive language capacity is improved.

In order to produce solutions to problems related to health, industry and environment, it is expected that students first explain situations causing the problems and relevant concepts with a correct terminology. Either traditional or contemporary teaching methods are used within the education process, that students can identify key concepts of course content is considered to facilitate students' following and comprehending the lesson. Concordantly, one of the effective guides widely used in curriculum development is concept maps demonstrating relationships between concepts (Novak & Cavas, 2008; Raud, Vodovozov & Lehta, 2013; Sisson & Ryan, 2015). Concept maps are considered useful in curricula; however, it seems impossible for students to clarify their perception of the study field with a simple visual presentation of curriculum components. Furthermore, to understand curriculum components and their relationships, students need more informative explanations along with propositions from one component to another (Raud & Vodovozov, 2012). On the other hand, it is emphasized to be appropriate that knowledge level of students is assessed through hierarchical glossary considered as a kind of thesaurus (Raud & Vodovozov, 2012; Raud, Vodovozov & Lehta, 2013). It is indicated that knowledge level is predictable through personal thesaurus presenting the collection of concepts familiar to individual in the relevant field (Raud & Vodovozov, 2012). Most of the items included in this kind of thesaurus are directly or indirectly interrelated, and a concept can reveal dozens of different concepts, which helps understanding knowledge level. Dictionaries involving this kind of hierarchical terms are generally like genealogy chart. A family tree diagram can represent conceptual relationships successfully starting from the root (ancestors) ending with the leaves (descendants) (Raud & Vodovozov, 2012).

In the study, personal thesaurus formation was used to help predict and assess student's knowledge level in chemistry subjects. 9th grade chemistry curriculum comprises of subjects that enable review of subjects and concepts given as fundamentals of science, and that students need in daily life scientifically. It is defined, in curriculum, as "to use knowledge and skills acquired in chemistry lesson to explain events regarding daily life, health, industry and environment." Accordingly, students are expected to evaluate and express negative and positive reflections of chemical activities on life. However, it is necessary for students to have a specific terminological basis considering their levels in order to actualize the purposes of chemistry lesson. At this point, two situations to be questioned appear. The first is that students recognize the key concepts of the unit, and the second is that they can define them. It is acknowledged as one of the first steps to activate the learning mechanism in student mind that student knows key concepts of a unit. That student defines the key concepts or reaches a correct definition or explanation by finding a reliable resource -except for the teacher- can be considered as an indicator that student takes the responsibility for learning. This study involves a conceptual thesaurus task performed to identify student perception and awareness during the lesson. The purpose of the study is to investigate whether students are aware of the key concepts offered in the 9th grade chemistry lessons during the first and second semesters, and whether they can define these concepts accurately. In the literature, there is plenty of research regarding concept-related thesaurus formation. These studies are mostly in the fields of language learning (Griggs, Bujak-Johnson& Proctor, 2004; Keränen, 2005; Miller, 2009; Karaduz & Yildirim , 2011; Chainikova, Zatonskiy, Mitiukov & Busygina, 2018; Milic, Glusac & Kardos, 2018); however, a limited number of studies are related to terminology of a specific scientific field (Nadiya, 2011; Raud & Vodovozov, 2012; Raud, Vodovozov & Lehta, 2013). Therefore, it is believed that the relevant study is important in that it contributes to the field of chemistry teaching and sets an example for the use of thesaurus as a reference in the field of education.

The purpose of the study is to investigate whether students recognize the key concepts of chemistry delivered to them during instruction and to evaluate the accuracy of their scientific definitions for these concepts. Within the scope of this purpose, the research questions were as follows:

- Can students accurately identify the key concepts in the units of 9th grade chemistry lesson? (receptive language development)
- How scientific are students' definitions or explanations for the key concepts they have recognized? (productive language development)

2. Method

In order to determine which key concepts students could recognize within the context of 9th grade chemistry lesson and to examine to what extent they could describe the key concepts in the relevant units, descriptive method was utilized. In this descriptive study, basic statistics were used to identify the existing state. Lessons were delivered by the teacher so as to prevent researcher bias in the study. Lesson plans were designed properly by the researcher so that the concepts explained and examples given in the group could reflect the curriculum, and lessons were covered within the framework of this planning.

2.1 Research Design

The study was conducted with 30 9th-grade students as 13 females and 17 males at the ages of 14-15 studying at a vocational high school during the fall and spring semesters of 2018-2019 academic year. In the study, since students' recognition of key concepts during teacher's instruction pursuant to the curriculum requirements was investigated, students were given personal thesaurus formation as a performance task. Within the context of the task, students were requested to determine the key concepts that they learned in chemistry lesson and write their definitions or explanations for these concepts in their dictionaries. The study was based on the lesson content depending on the chemistry curriculum. Students were informed, at the beginning of the semester, that the study would last until the end of the second term, and that they would have the chance to make changes on the concepts they learned during the academic year and to complete their work. At the end of the second semester, researchers received the personal dictionaries that students prepared. Within the scope of the study, the chemistry curriculum taken as a basis comprised of 5 units, and students were expected to recognize and describe the 68 key concepts offered in the curriculum. Unit names, number of learning outcomes, lesson hours and unit-based key concepts in the curriculum are presented in Table 1.

Table 1: List of key concepts based

Unit No	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5
Unit Name	Science of Chemistry	Atom & Periodic System	Interactions between Chemical Species	States of Matter	Nature & Chemistry
Number of outcomes	7	5	11	10	5
Lesson hours:	6	16	22	20	8
Percentage:	8	22	31	28	11
Key Concepts	Compound	Absorption	Nonpolar Covalent Bond	Fluidity	Chemical Contaminant
	Scientist	Nonmetal	Bond Energy	Avogadro number	Contamination
	Substance/ Matter	Atom	Valence electron	Relative Humidity	Global Warming
	Element	Atom Model	Hydrogen Bond	Pressure	Greenhouse Effect
	Symbol	Atomic Radius	Ion	Vapor Pressure	Hard Water
	Formula	Electron Affinity	Ionic Bond	Vaporization	Soft Water
	Alchemy	Electron	Chemical Bond	Freezing	
	Chemistry	Electro-negativity	Covalent Bond	Melting	
	Safety in Laboratory	Emission	Metallic Bond	Expansion	
		Group	Intermolecular Interaction	Volume	
		Ion	Polar Covalent Bond	Boiling	
		Ionization energy		Deposition	
		Isobar		Mole	
		Isoelectronic		Absolute Temperature	
		Isotone		Humidity	
		Isotope		Plasma	
		Metal		Sublimation	
		Neutron		Viscosity	
		Periodic system		Condensation	
		Period			
		Proton			
		Theory			
		Semimetal			
Number of concepts per unit	9	23	11	19	6
Total number of concepts	68				

2.2 Population and Sample/Study Group/Participants

The study was conducted with 30 9th-grade students as 13 females and 17 males at the ages of 14-15 studying at a vocational high school during the fall and spring semesters of 2018-2019 academic year.

2.3 Data Collection & Analysis

Units with the key concepts that students were expected to include in their personal thesaurus were Science of Chemistry, Atom and Periodic System, Interactions between Chemical Species, States of Matter, and Nature and Chemistry. Concepts given for each unit in the curriculum were determined as the basic concepts that students needed to know and include in their dictionaries. Basically 68 concepts were presented in the 9th grade curriculum, and students were also expected to recognize and define these 68 concepts.

Expectations from students: In accordance with the curriculum requirements at their education level, students were requested to;

- distinguish key concepts in the units,
- look up their definitions in the right resources and express them in written form,
- keep these concepts and explanations in their personal thesaurus for 2 semesters,
- complete their study in all units methodically and consistently.

Necessary controls were made after each unit by the researchers.

Concept list compilation for thesaurus, resource selection for definitions: In this section of the study, the criteria determined for students' including concepts of the 9th grade chemistry curriculum in their dictionaries are presented.

1) The criterion for a concept to be involved in personal thesaurus is that it is among the key concepts offered in the curriculum. However, a concept that is not in the curriculum but specified by students can be accepted if it fulfils the conditions below. The selection of the concepts is based on;

their scientific and course-specific semantic value,
their use in the curriculum (MEB, 2018), course book (The Commission, 2018) unit content explanations,
and their use preferred by teacher in instruction.

2) While controlling dictionaries, for the resources from which definitions were taken to be reliable, students were recommended main resources, reference resources, course books, journals and articles on relevant web pages. It was indicated that other definitions would not be evaluated within the scope of the study.

Evaluation: While personal thesauruses prepared by students were being evaluated, key concepts in the curriculum were approved. When the number of key concepts recognized by students and the ones in the curriculum was equal, full points were given for each unit. The formula used is explained below.

Results were determined through the formula "Q = a / n."
Success rate; Q
Student's accurate recognition of key concept: a
Number of key concepts in the unit: n

While student success was being assessed, success rate below 0,5 was estimated to be insufficient, 0,51-0,79 as sufficient and over 0,8 as high level. When the rate was over 0,51, it was identified as a sign of student's being at a sufficient level. Student who recognized all the key concepts in a unit received 1 (one) full point. A student who determined all the key concepts in all units was expected to have maximum 5 (five) full points.

In order to determine the accuracy of definitions for the key concepts in personal thesauruses, evaluation was made by researchers and two chemistry teachers through discussion, and results were recorded after reaching a consensus. Researchers discussed the responses for each definition with reference resources, and then, chemistry teachers were requested to control the same data. Consequently, for definitions of the key concepts included in student dictionaries, "consensus among experts" and "divergence among experts" were specified. At this point, reliability was calculated through the formula of Miles and Huberman (1994), and reliability coefficient was found to be 0,91 indicating the reliability of the study. Upon control of researchers and field experts, analysis was completed by reaching a consensus in definitions with divergence.

This section should state how, when and under which circumstances the data collection tools are used. If the study is experimental, the experiment or the control conducted should be detailed. Not only the procedures included in experimental group(s) but also the control group(s) should be stated.

3. Findings

In this section, the key concepts of the units included in the research were evaluated individually, and student success in two semesters was presented by making an overall analysis with a holistic approach.

Under the title of Unit Evaluation Based on Key Concepts, findings for each unit were given in tables. Key concepts in the curriculum were presented in the tables with the number of concepts included in personal thesauruses. Moreover, in the column titled "use of concepts associatively," the number of different concepts that students included in their thesaurus by taking the relevant key concept as basis. For instance, student did not include the key concept of substance but included corrosive substance, caustic substance, toxic substance, noxious substance. The number of these concept groups is presented under the relevant title.

In "students' recognition levels of key concepts," a unit-basis evaluation was made for each student by using the Q= a/n formula to determine student success, and each student's level of competence in concept recognition for two semesters was categorized.

3.1 Unit Evaluation Based on Key Concept

3.1.1 Unit 1: Science of Chemistry

In Science of Chemistry unit, 10 key concepts in total were identified; these were: "Compound, Scientist, Matter/Substance, Element, Symbol, Formula, Alchemy, Chemistry, Laboratory Safety, and Laboratory." In Table 2, students' recognition of key concepts in Science of Chemistry unit is presented.

Table 2: Recognition of Key Concepts in Science of Chemistry Unit 1

Nr.	Key Concepts	Number of Students Including the Relevant Concept	Use of Concept Associatively
1.	Compound	18	11
2.	Scientist	----	----
3.	Matter/Substance	16	41
4.	Element	15	3
5.	Symbol	1	----
6.	Formula	6	----
7.	Alchemy	29	----
8.	Chemistry	20	86
9.	Laboratory Safety	----	----
10.	Laboratory	3	----

When student works were examined, it was observed that scientist and laboratory safety were not selected by students as key concepts among others in the relevant unit, and not included and defined in their dictionaries. "Symbol" was one of the main key concepts of the unit but only one (1) student included it in his/her work and made its definition. It was identified, at the end of the unit, that most of the students (29) selected "alchemy" as a key concept and recorded it in their work with its definition. Students began chemistry lesson at secondary school, and met "chemistry" concept scientifically for the first time. However, 20 students involved it in their work. It was encountered and explained in different contexts for 86 times in total. Students selected and described chemistry-related concepts like "organic chemistry, analytical chemistry, environmental chemistry, textile chemistry, food chemistry, geochemistry, biochemistry and modern chemistry" and examined them within the context of key concepts. Nonetheless, the number of students who included "chemistry" as the basic concept was limited to 20. Similarly, "compound" as one of the main key concepts of the unit was defined by 18 students, and compound-related concepts like “ionic compound, organic and inorganic compound” were presented by 11 students without definition of compound itself. Another basic concept “substance/matter” was selected as key concept and explained by 16 students. Concepts related to matter/substance like “corrosive matter, organic substance, foreign matter, harmful substance, colorant substance, radioactive substance and pure substance” were described by students among key concepts. Moreover, there were some works involving relevant concepts without defining “substance/matter” itself. “Element” as another basic concept was explained by 15 students while the related “radioactive element” term was defined by 3 students without definition of element itself. The concept of “formula” in the first unit was recognized and defined by 6 students, and “laboratory” by 3 students. There was no key concept that was identified commonly and described accurately by all 30 students.

It was observed that key concepts selected for Science of Chemistry unit were generally expressed with correct definitions in students’ works, which indicated that they described the concepts through the right resources. On the other hand, some key concepts were presented but explained inaccurately. 4 students were identified to have problems with definitions of the key concepts in the first unit; the relevant data are presented below. Inaccurate definitions belonged to the concepts of element, chemistry and compound.

S17: “Element: It is the structure formed when the same kind of elements come together.”

S11: “Chemistry: It is the studies conducted in 1600s before scientific research. “

S11: “Compound: All substances are called compounds.”

S21: “Element: It is a symbolic sign.”

S30: “Element: It is a particle with negative charge.”

3.1.2 Unit 2: Atom and Periodic System

23 key concepts of the Atom and Periodic System unit were given in the curriculum as “Absorption, Nonmetal, Atom, Atom model, Atomic radius, Electron, Electron affinity, Electronegativity, Emission, Group, Ion, Ionization energy, Isobar, Isoelectronic, Isotone, Isotope, Metal, Neutron, Periodic system, Period, Proton, Theory, Semimetal.” In Table 3, students’ recognition of key concepts for Atom and Periodic system is presented.

Table 3: Recognition of Key Concepts for Atom and Periodic System

Nr	Key concepts	Number of students	Use of Concept Associatively
1	Absorption	----	----
2.	Nonmetal	3	3
3	Atom	30	39
4	Atom model	----	----
5	Atomic radius	15	----
6	Electron	20	14
7	Electron affinity	15	----
8	Electronegativity	8	----
9	Emission	----	----
10	Group	10	----
11	Ion	12	62
12	Ionization energy	15	----
13	Isobar	----	----
14	Isoelectronic	----	----
15	Isotone	----	----
16	Isotope	15	15
17	Metal	6	20
18	Neutron	22	----
19	Periodic system	1	----
20	Period	10	----
21	Proton	19	----
22	Theory	4	----
23	Semimetal	1	----

Among these concepts; “absorption, atom model, emission, isobar, isoelectronic, and isotone” were not selected as relevant key concepts and included in any student works. “Periodic system” and “semimetal” among the main key concepts of the unit were involved in personal thesaurus of only one (1) student. “Nonmetal” was recognized and defined by 3 students, “theory” by 4 students, “electronegativity” by 8 students, “period” and “group” by 10 students each, “atomic radius,” “electron affinity,” “isotope” and “ionization energy” by 15 students each. “Ion” was recognized and described by 12 students but also used in different contexts by others for 62 times without being explained. Although concepts of “ionic bond, ionization energy, ionic, ionic compound, ion dipole interaction” were explained as key concepts within the scope of the study, the number of students who examined and defined ion concept forming the basis for the subject was limited to 12. “Electron” was identified as a key concept by 20 students. 14 students who did not determine it as a key concept included and explained electron-related concepts like “electronegativity, electron affinity, electron activity” in their dictionaries. 6 students defined “metal” in their works whereas 20 students did not include it but explained related concepts like “metallic bond and semimetal.”

All 30 students participating in the study identified “atom” concept in the unit of Atom and Periodic System and included it in their thesauruses.

When the key concepts that students selected for atom and periodic system unit were evaluated within the context of the study, it was observed that very few concepts were presented and explained accurately. When it was evaluated overall, students made correct definitions for few concepts; mistakes were detected in their statements. It was identified that 4 students described key concepts of the 2nd unit inaccurately. Those inaccurate descriptions were for atom, neutron, electron affinity, ion and electronegativity.

> S16: “Atom: It is the constituent that forms elements and is divisible.”
> S9: “Neutron: They are the particles that move fast in a specific orbit around the nucleus with -1 charge and little mass. Their symbol is e-.”
> S18: “Electron affinity: It is what comes out when a gaseous atom takes e-.”
> S17: “Electronegativity: Atom constituting a molecule or compound pulls electrons in another atom towards itself.
> “Ion: They are atom-sized chemicals with electric charge.”

3.1.3 Unit 3: Interactions between Chemical Species

11 key concepts were involved in the curriculum for Interactions between Chemical Species unit. These were “Nonpolar covalent bond, bond energy, valence electron, hydrogen bond, ion, ionic bond, chemical bond, covalent bond, metallic bond, intermolecular interaction, and polar covalent bond.” In Table 4, students’ recognition of key concepts in Interactions between Chemical Species unit is presented.

Table 4: Recognition of Key Concepts in Interactions between Chemical Species Unit

Nr.	Key Concepts	Number of Students	Use of Concept Associatively
1.	Nonpolar covalent bond	4	----
2.	Bond energy	----	----
3.	Valence electron	----	----
4.	Hydrogen bond	7	----
5.	Ion	12	62
6.	Ionic bond	18	----
7.	Chemical bond	2	----
8.	Covalent bond	18	8
9.	Metallic bond	15	----
10.	Intermolecular interaction	----	----
11.	Polar covalent bond	4	----

Among these concepts, "bond energy, valence electron, intermolecular interaction" were not selected as relevant key concepts and included in any student works. Even though "chemical bond" was a key concept of the unit, it was identified and described by only 2 students. "Polar covalent bond and nonpolar covalent bond" were recognized and defined by 4 students, "hydrogen bond" by 7 students, "metallic bond" by 15 students, "ionic bond and covalent bond" by 18 students. Students who did not include "covalent bond" in their works explained concepts of nonpolar and polar covalent bond. Among the concepts of unit 3, there was "ion" which was also one of the key concepts in unit 2. It was noteworthy that ion was emphasized in both units; however, students did not determine it as a key concept but explained it in different ways. Details related to the concept of ion are given below Table 2. In this unit, there was no concept identified and described accurately by all 30 students.

When definitions for the key concepts included correctly in student dictionaries within the context of Interaction between Chemical Species unit were evaluated, it was observed that students, in general, defined few concepts accurately. 8 students were identified to have inaccuracy in their definitions, and relevant statements are presented below. Those inaccurate definitions were for the concepts of covalent bond, metallic bond, hydrogen bond and ionic bond.

S1: "Covalent Bond: It is the common use of electrons by substances.

S2 & S7: "Covalent Bond: The bond formed as a result of electron cooperation between nonmetal and metal element atoms is called covalent bond.

S11: "Metallic Bond: It is the chemical substance formed by bonds."

S12: "Hydrogen Bond: Electron negativities of Fluorine, Oxygen, and Nitrogen are high."

S15: "Metallic Bond: It is the chemical bond holding one or more atoms between metals."

S20: "Covalent Bond: It is the bond created as a result of electron cooperation between nonmetal and metal element atoms."

S23: "Covalent Bond: It is the chemical bond characterized through sharing of one or more atoms between two atoms.

S27: "Ionic Bond: It is the chemical bond formed during electron exchange between metal and metal.

3.1.4 Unit 4: States of Matter

For States of Matter unit, there were 11 key concepts offered in the curriculum. These were fluidity, Avogadro number, relative humidity, pressure, vapor pressure, vaporization, freezing, melting, expansion, volume, boiling, deposition, mole, absolute temperature, humidity, plasma, sublimation, viscosity, and condensation. In Table 5, students' recognition of the key concepts in State of Matter unit is presented.

Table 5: Recognition of the key concepts in State of Matter unit

Nr.	Key Concepts	Number of Students	Use of Concept Associatively
1.	Fluidity	----	----
2.	Avogadro number	----	----
3.	Relative humidity	4	----
4.	Pressure	13	----
5.	Vapor pressure	----	12
6.	Vaporization	7	----
7.	Freezing	3	----
8.	Melting	3	----
9.	Expansion	----	----
10.	Volume	18	----
11.	Boiling	7	----
12.	Deposition	1	----
13.	Mole	1	----
14.	Absolute temperature	----	----
15.	Humidity	3	12
16.	Plasma	7	----
17.	Sublimation	4	----
18.	Viscosity	12	----
19.	Condensation	12	----

Among these concepts; fluidity, Avogadro number, vapor pressure, expansion, and absolute temperature were not selected as relevant key concepts and included in thesauruses by any students. Deposition and mole were recognized and described by 1 student; humidity, freezing and melting by 3 students; relative humidity and sublimation by 4 students; "vaporization, boiling and plasma" by 7 students; "viscosity and condensation" by 12 students; "pressure" by 13 students; and "volume" by 18 students. Furthermore, "vapor pressure" was not selected as a key concept but "equilibrium vapor pressure" was identified and explained by 12 students.

In this unit, there was no key concept that all 30 students identified and described accurately.

Students defined totally 14 out of 19 key concepts in the States of Matter unit. It was observed that students explained concepts correctly in general sense; however, some definitions were mistaken. 7 students were identified to have problems while describing some concepts of the 4th unit, which were mole, pressure and condensation. Inaccurate definitions for the relevant concepts are presented below.

S8: "Mole: It is the unit used for chemical calculations of substance amount."

S2, S7, S13 & S26: "Pressure: It occurs when gas collides with the container surrounding it."

S11: "Pressure: When we perform an impact on something, it is called pressure."

S16: "Pressure: Gas fills the container it is in, takes its volume and shape because gas molecules are continuously on the move."

S16: "Condensation: It is the mass per unit volume of a substance."

3.1.5 Unit 5: Nature and Chemistry

Totally 6 concepts were offered in the curriculum for Nature and Science unit. These concepts were chemical contaminant, contamination, global warming, greenhouse effect, hard water, and soft water. In Table 6, students' recognition of key concepts in Nature and Chemistry unit is presented.

Table 6: Recognition of key concepts in Nature and Chemistry unit

Nr.	Key concepts	Number of students	Use of Concept Associatively
1.	Chemical contaminant	None	----
2.	Contamination	None	----
3.	Global warming	None	----
4.	Greenhouse effect	None	----
5.	Hard water	None	----
6.	Soft water	None	----

Concepts of this unit presented in Table 6 were not identified as key concepts and included in any student dictionaries. None of the 30 students who participated in the study was able to recognize and define the relevant key concepts in the curriculum.

3.2 Students' Recognition Levels of Key Concepts

Students' recognition of key concepts is summarized in Table 7 & 8 presented in this section. In Table 7, each student was coded, total number of concepts included by each student was given, and student success for each unit was assessed with Q= a/n formula. While using this formula, success was calculated both for the key concepts included in personal thesauruses (Q1) and for the relevant concepts in the unit (Q2). However, while total success rate was being calculated, assessment was made based on the number of key concepts in the units (Q1).

Based on Q1 value obtained in Table 7, the number of students at sufficient level was examined, and Table 8 was created. That Q1 values determined in Table 7 were over 0,5 was considered as a sign for student's being successful or at sufficient level (Q>0,8: very high; 0,79>Q>0,51: sufficient; Q<0,50: insufficient). The number of students at sufficient levels in receptive and productive vocabulary steps is presented in Table 8.

In Table 7, assessment of student success based on the number of concepts per unit is presented. In this section, each student's success in recognizing key concepts for each unit was measured.

Table 7: Assessment of student success regarding the number of key concepts per unit included in personal thesaurus accurately

St. No.	Number of concepts in personal .	Unit 1		Unit 2		Unit 3		Unit 4		Unit 5		Total
		Q= a/10		Q= a/23		Q= a/11		Q= a/19		Q= a/6		Q= a/68
		Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1	Q2	Q1
S1	40	0,20	0,30	0,13	0,35	0,46	0,63	0	0,26	There are no key concepts or relevant concepts identified.		0,79
S2	42	0,20	0,30	0,09	0,43	0,27	0,55	0,16	0,47			0,72
S3	56	0,20	0,40	0,43	0,61	0,18	0,63	0,16	0,37			0,97
S4	37	0,30	0,60	0,35	0,52	0,09	0,36	0,26	0,53			1,0
S5	50	0,50	0,70	0,13	0,26	0,09	0,46	0	0,47			0,72
S6	46	0,30	0,60	0,43	0,73	0,18	0,55	0,26	0,37			1,17
S7	40	0,20	0,30	0,09	0,35	0,27	0,55	0	0			0,56
S8	84	0,70	0,90	0,61	0,87	0,45	0,72	0,16	0,89			1,92
S9	56	0,50	0,60	0,30	0,61	0,27	0,72	0,37	0,37			1,44
S10	48	0,40	0,60	0,43	0,52	0,27	0,63	0,47	0,84			1,57
S11	41	0,40	0,60	0,17	0,35	0,09	0,27	0,16	0,37			0,82
S12	49	0,30	0,50	0,43	0,61	0,18	0,52	0,11	0,47			1,02
S13	39	0,20	0,30	0,09	0,26	0,55	0,81	0,21	0,26			1,05
S14	80	0,50	0,70	0,35	0,61	0,27	0,63	0,16	0,26			1,28
S15	31	0,30	0,40	0,43	0,61	0,09	0,27	0,21	0,32			1,03
S16	77	0,60	0,80	0,52	0,73	0,46	0,72	0	0,26			1,58
S17	73	0,70	0,80	0,52	0,87	0,09	0,36	0,47	0,26			1,78
S18	65	0,60	0,70	0,48	0,52	0,09	0,36	0,58	1,0			1,75
S19	39	0,30	0,60	0,35	0,61	0,36	0,72	0,26	0,26			1,27
S20	40	0,20	0,40	0,26	0,43	0,18	0,72	0,05	0,26			0,69
S21	27	0,30	0,50	0,13	0,43	0,27	0,63	0	0,42			0,70
S22	32	0,30	0,40	0,35	0,73	0,09	0,27	0,05	0,37			0,79
S23	33	0,30	0,60	0,35	0,52	0,0	0,27	0	0,11			0,65
S24	91	0,50	0,70	0,30	0,52	0,46	0,63	0	0			1,26
S25	35	0,20	0,30	0,22	0,43	0,36	0,72	0,47	0,73			1,25
S26	46	0,30	0,50	0,09	0,26	0,0	0	0	0			0,39
S27	45	0,50	0,80	0,39	0,61	0,27	0,63	0,16	0,21			1,32
S28	40	0,20	0,40	0,26	0,43	0,18	0,27	0,05	0,26			0,69
S29	86	0,30	0,40	0,22	0,43	0,19	0,55	0	0			0,71
S30	56	0,10	0,30	0,17	0,35	0,27	0,55	0,21	0,63			0,75
TOTAL		**10,6**		**9,07**		**6,98**		**4,99**		**0**		**31,64**

As it is inferred from Table 7, even though students could not recognize the key concepts offered in the curriculum, they included different concepts of the relevant unit in their works. In Table 7, the number of concepts that each student had in their dictionaries was given. However, since each of these concepts was not the right key concepts, students' success rates were calculated as Q1 and Q2. When personal thesauruses of students were examined based on Q1 value regarding the key concepts in the curriculum, in Science of Chemistry unit (Unit 1), 9 students (S5, S8, S9, S14, S16, S17, S18, S24, S27); in Atom and Periodic system unit (Unit 2), 3 students (S8, S16, S17); in Interactions between Chemical Species unit (Unit 3) and States of Matter unit (Unit 4), 1 student for each (S13 and S18 respectively) were found to be at sufficient level.

When the number of concepts that students identified independently from key concepts in units was examined, it was observed that students included more concepts in their thesauruses. Considering these concepts, the number of students whose Q2 value regarded as success rate was over 0,51 was 15 in Science of Chemistry unit (Unit 1), 17 in Atom and Periodic system unit (Unit 2), 20 in Interactions between Chemical Species unit (Unit 3) and 6 in States of Matter unit (Unit 4). These students' success levels based on Q2 value were found to be sufficient or high.

That vocational high school 9th grade students identified the key concepts in the unit in accordance with the curriculum was considered as receptive vocabulary and investigated within this context. That students accurately describe or define the key concepts they identified was considered as productive vocabulary. Based on Q1 value obtained in Table 7, the number of students at sufficient level was examined, and Table 8 was formed. Q1 value over 0,5 was regarded as a sign for students' being successful or at sufficient level (Q>0,8: high; 0,79>Q>0,51: sufficient; Q<0,50: insufficient), and the number of students with sufficient level for receptive and productive vocabulary was presented in Table 8.

Table 8: General evaluation of the task given to students

Task type		Unit 1		Unit 2		Unit 3		Unit 4	
		Q≥ 0,51	Q≤0,51	Q≥ 0,51	Q≤0,51	Q≥ 0,51	Q≤0,51	Q≥ 0,51	Q≤0,51
Receptive vocabulary	Identifying key concepts in a unit	9 student	21 student	3 student	27 student	1 student	29 student	1 student	29 student
Productive vocabulary	Defining a term	26 student	4 student	26 student	4 student	24 student	6 student	23 student	7 student

When students' personal dictionaries were examined regarding Q1 value in Table 8 based on the key concepts offered in the curriculum; 9 students in Science of Chemistry unit (Unit 1), 3 students in Atom and Periodic system unit (Unit 2), and 1 student in both Interactions between Chemical Species (Unit 3) and States of Matter units (Unit 4) were found to be at sufficient level. In Nature and Chemistry unit (Unit 5), there was no student who could identify the right key concepts. As it is presented in Table 8, the number of students who were considered as insufficient was 21 in Unit 1, 27 in Unit 2, and 29 in Unit 3 and 4; they were evaluated in the category for those who identified an inadequate number of concepts.

In Unit 1 titled as Science of Chemistry, the key concepts selected by 9 students who were considered successful for identifying concepts at an adequate level were "compound, substance/matter, element, formula, alchemy, chemistry and laboratory." Students who identified an adequate number of concepts could not recognize "scientist, symbol, and laboratory safety" during the instruction or did not consider them as key concepts.

In Unit 2 called Atom and Periodic System, the key concepts selected by 3 students who were successful at determining an adequate number of concepts were "atom, atomic radius, electron, electron affinity, group, ion, ionization energy, isotope, neutron, proton, and period." Other concepts in the unit were not recognized and selected by students identifying the concepts at a sufficient level. These terms that students did not prefer as key concepts were "Absorption, Nonmetal, Atom model, Electronegativity, Emission, Isobar, Isoelectronic, Isotone, Metal, Periodic system, Period, Theory, and Semimetal."

In Unit 3 titled as Interactions between Chemical Species, the key concepts selected by 1 student considered successful for identifying concepts at an adequate level were "hydrogen bond, ion, ionic bond, covalent bond, and metallic bond." Other concepts in the unit were not recognized and selected by students at sufficient level. They were "nonpolar covalent bond, bond energy, valence electron, chemical bond, intermolecular interaction and polar covalent bond."

In Unit 4 called States of Matter, the key concepts selected by 1 student considered successful for identifying concepts at an adequate level were “relative humidity, pressure, vaporization, freezing, melting, volume, boiling, mole, humidity, plasma, sublimation, viscosity, and condensation”. Other concepts that were not recognized and selected by students were “fluidity, Avogadro number, vapor pressure, expansion, absolute temperature, and deposition.”

In Unit 5 titled as Nature and Chemistry, there was no student who could determine an adequate number of key concepts. There were 6 key concepts in this unit; however, students did not recognize and include them in their definitions.

As it is stated in Table 8, identifying the key concepts was evaluated as receptive language, and defining the selected concepts as productive language. When the task given to students was evaluated based on each unit, it was observed that students failed to select the key concepts correctly; in other words, they were unsuccessful considering receptive language. That vocational school 9th grade students defined or described the key concepts they identified themselves was evaluated as productive language, and within this context, it was observed that students generally defined the unit concepts accurately in their personal thesauruses. When students’ receptive and productive language perceptions were compared, it was revealed that students were relatively more successful at productive language in comparison to receptive one.

4. Discussion and Conclusion

Formation of scientific language depends on that conceptual background is solid, and concepts are learned, described correctly and associated. The most effective way for students to improve conceptual competence scientifically is to recognize and explain accurately the concepts they have learned, and associate them with other concepts. In many studies, it was revealed that the main reason for students’ failure in chemistry lesson was that they could not learn the basic chemistry concepts precisely during instructions, and accordingly; they could not understand the higher level knowledge taught later on (Nakleh, 1992). Concepts that are the main elements of individual’s knowledge structure are examined as abstract and concrete concepts. Concepts like beaker, flame and metal can be given as examples for concrete concepts. This kind of concepts can develop as a result of individual’s own experiences. As for abstract concepts; atom, mole, chemical balance, oxidation and reduction can be considered as examples (Janiuk et al., 1993). In scientific research conducted (Bayram, Sokmen & Gurdal, 1998; Marck, 1986; Cantu & Herron, 1978), it was indicated that students could not learn abstract concepts without learning concrete ones completely, and that they could learn these concepts at the ages of 14 or 15 when their reasoning abilities developed. Regarding that students have difficulty in comprehending when many concepts are given in abstract terms at early ages, it is believed that rote learning of concepts especially in science lessons will lead to that concepts will be forgotten in the upcoming terms or misconceptions will be developed.

It is stated that actions in the curricula are based on the principle that human development is a whole (MEB, 2018). Features in different zones of human development interact with one another. For instance, language development affects and is affected by intellectual development. For this reason, teachers contribute to individual’s development with each activity that they perform in class. In the study, it is investigated to what extent students can recognize the concepts that they are expected to learn during instruction (receptive language development) and how they define the concepts that they have recognized (productive language development).

The study was conducted with 9^{th} grade students studying at a vocational high school during the 2018-2019 school year. Within the context of chemistry lesson, students were expected to identify the basic concepts in the curriculum, and explain these concepts. Considering the language aspect, in the first step, students’ chemistry-related receptive language during instruction, and in the second step, their productive language was evaluated. Students were informed about the task assigned to them at the beginning of the term based on the aforementioned issues; they were controlled at the end of each unit, and the thesauruses comprising of student records were collected as data at the end of the term.

When the task assigned within the scope of the study was evaluated overall, it was hard to state that vocational high school students were successful at identifying unit-based key concepts in the curriculum. Even though they made an effort to actualize the task assigned to them, only 9 students were found to be at sufficient level in the first unit called Science of Chemistry, and the others could identify an inadequate number of concepts. The number of students who could determine the concepts at an adequate level was 3 after the first unit, and 1 in the other units. In the last unit titled as Nature and Chemistry, students could not recognize and define any of the concepts in the curriculum. The rest of the students could not identify the key concepts, indicating that they passed the basic concepts without noticing during instruction and could not form the conceptual background. In other words, students had difficulty in following the lesson because they could not recognize the subject and content in question.

It was determined that students did not recognize the key concepts of the subject while performing the task assigned to them. Sampling group students began taking chemistry lesson at secondary school, and met "chemistry" concept in scientific sense for the first time then. However, 20 students included and defined "chemistry" in their dictionaries. The concept was encountered in student works 86 times in different contents. Students defined chemistry-related concepts such as "organic chemistry, analytical chemistry, environmental chemistry, textile chemistry, food chemistry, geochemistry, biochemistry, modern chemistry…" and examined them within the context of key concepts; nevertheless, the number of students who defined and examined the chemistry concept as the basis of the subject was limited to 20. 8 students explained other relevant terminology without describing "chemistry" concept. In Unit 3 called Interactions between Chemical Species, the key concepts were "chemical bond and intermolecular interactions"; however, students selected and defined "ion dipole interaction and dipole-dipole interaction" as key concepts without explaining the former ones. Students were supposed to know the concept of chemical bond primarily in this subject. They needed to internalize and make sense of it so that they could form the background for other concepts. Likewise, students were expected to think about intergranular interaction after they knew the concepts of ion and molecule and their meanings. Although teacher delivered the subjects at their own pace during instruction, students struggled to understand or explain higher level concepts without getting the basic ones as they could not form the basis, which prevented scientific content from going beyond memorization. For instance, one of the key concepts in second and third units was "ion". Students defined "ionization energy, ionic bond and ionization" concepts without recording and explaining the key concept "ion" in their works. Another concept was "vapor pressure", and students included "equilibrium vapor pressure" concept and its description in their dictionaries without understanding the basic concept first. When concept descriptions were checked, it was observed that students reached the right resources and mostly included accurate statements. On the other hand, it was determined that students tried to define the concepts with a terminology that they were unfamiliar with, which was like struggling to keep the leaves green on a tree without root. The relationship between knowledge and concepts resembles to the one between leaves, branches and root of a tree. Concepts and propositions indicating relationships between concepts in human mind are similar to that leaves connect to branches, reach the tree trunk through them and spring to life with the sap coming from the deeps. The relationship between tree and leaves is like a knowledge network or construction. Information given in the basic subjects of chemistry is based on concepts. These basic concepts will enable what individuals learn to connect with the soil and activate the sap. Therefore, it is of great importance that concepts are known accurately to understand scientific knowledge.

This study is important in three different aspects. First, students can recognize and associate the key concepts of the subject area; second, they have the terminological competence in chemistry for the future; and third, knowledge that students have in 9^{th} grade chemistry subjects is improved and reinforced. The first result obtained in this study is that students, in general, could perceive the concepts superficially. In order to achieve the aforementioned outcomes, it is necessary for students to expand their awareness for the lesson. One of teacher's responsibilities should be to ensure the subject-related concepts to be recognized. Students do not need to define a term that they hear a lot in daily life or construct it in their mind with its scientific meaning during instruction. In this case, basic concepts should be presented interactively to ensure students' learning these concepts and to provide a sound basis for science. For this purpose, it is recommended that content of the concept is treated interactively, and students deliver a subject-related speech to explain the concept as a monologue. It is anticipated that the result of the study will change when researchers to continue investigating this subject include verbal expressions of students by adding a parallel application to the relevant thesaurus task. Another result of the relevant study is that the number of concepts delivered to vocational high school students is high. Students cannot learn the concepts even superficially.

An effective result of the study conducted was that students were eager to perform the task assigned to them. All the students tried to complete their thesaurus-formation task precisely. However, it is obscure that the task contributed to students cognitively. Since meaningful learning of students did not occur in this study, no subject learned during instruction remained until the end of the term. Even the knowledge that could be useful in student's life was learned during instruction temporarily without awareness and forgotten later on as student was exposed to a lot of subjects and concepts. Nature and Chemistry as the last unit of the 9th grade consists of contents necessary for individual's life and for every citizen to respect the world.

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