Measuring Understanding of Electron Distribution of Atoms among Pre-service and In-Service Physical Science Teachers Using Representational Task

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Abstract: ***Representation is to symbolize, to depict as, and to help describe an idea that reinforces the descriptive, symbolic and recognizable role of representations in explanations. Representations, which are not literal interpretations nor considered as the real thing, are used in chemistry depicted as models, analogies, equations, graphs, diagrams, pictures and simulations. These representations serve as essential avenues of measuring the extent of understanding in the disciplinal content as alternative to traditional assessment methods (Lansangan, 2018). Kozma (2003) proposed a conceptual structure showing representational competence into characteristic patterns of representational use at five stages or level, which was the basis of the current study in constructing representational tasks for measuring understanding of the electron distribution of atoms. The study employed the mixed-method sequential explanatory design. The representation task rubric was developed, validated and pilot tested to 30 Pre-service physical sciences students and 30 in-service physical science teachers. Both quantitative and qualitative data collected substantiate the conclusion that the task feasibly corresponds to the rubrics developed. Among the respondents' takeaway of the experience is about the importance of organizing and re-organizing their thoughts on the concepts and pictures out the idea, giving importance in checking and correcting misconceptions, measuring their level of understanding and reflecting on how to improve their understanding on the topic.***

Keywords: Science representations, Conceptual structure, Electron distribution of atoms

1. Introduction

The theoretical basis of this study is a constructivist approach, which is rooted in the belief of the existing knowledge of learners, is a major factor in determining the learning outcomes (Ausabel, 1968). Learners have pre-conceived knowledge regarding science that leads them to misconception.

Constructing knowledge and understanding concepts from experience which is unique to each individual relates to how a learner understand concepts through visual language. Constructivist approach in teaching in all level is needed because the conventional pedagogical practices of teaching emphasize learning of answers more than the exploration of questions (Singh and Yaduvanshi, 2015). Utilizing these approach encourages understanding the text deeply and not just be reading it.

It is encouraged to put emphasis in constructivism and hands-on inquiry-oriented instruction to promote children's conceptual knowledge by building on prior understanding, active engagement with the subject content, and applications to real world situations has been advocated in science lessons. The following are important to consider in the development of an alternative assessment tool;(a) identifying students' views and ideas. (b) Creating opportunities for students to explore their ideas and to test their robustness in explaining phenomena, accounting for events and making prediction; (c) providing stimuli for students to develop, modify and where necessary, change their ideas and views; and, (d) supporting their attempts to re-think and reconstruct their ideas and views.

Chemistry is regarded as a difficult subject. The foundations of understanding changes in nature stems in understanding the atoms. The discipline has specific mathematical operations, specialized vocabulary, and unique representations (Lansangan, 2018). Because of the abstract nature of chemistry that is based on structures, calculations and grounded in theoretical basis, learners tends misunderstand the main theories of atoms which lads the learners in not pursuing further studies in the discipline.

This study contains the developed representational activity and its corresponding rubrics that will allow assessing further the understanding of the learners on the electron distribution of atom. The developed assessment tool is an alternative assessment tool for outcomes based education that can evaluate the understanding of learners through illustrations of their perception of the electron distribution of atoms.

Representations paved the way to developing understanding of science further, this methods bridges gap in the understanding of the expert regarding the science principle to the public. In chemistry, representations are important in the relationship of chemistry and the understanding of the scientific community. Representations can provide clear explanations of the concept to break misconceptions.

Science is a very important part of a learner's foundation in education. It involves numerous concepts in different disciplines such as Earth Science, Biology, Chemistry, Physics, etc. When these concepts are clumped together, some learners find it difficult to understand. It is of importance to be able to think of an easier way to make students understand these concepts especially when they are studied altogether. Images and illustrations are considered to be an important didactic tool in teaching science (Pintó and Ametller, 2002).

Utilization of images to aid learning in different manuscripts and journals are required in graphical abstracts to depict a concept and accompany studying (Madhusoodanan, 2016). Illustration greatly helps in depicting and understanding concepts accompanied by our prior knowledge. Leaners find it easier to explain central scientific knowledge with help of visual representations as long as these representations are connected with their prior knowledge. Sometimes, they can discover new concepts from these visual representations as they explain it (Von Zeipel, 2014). People who also work and study on the molecular level often use illustrations as their first material for visualization of concepts that other researchers might have worked on for many years (Madhusoodanan, 2016).

Pictures in illustration can stimulate discussions that pertain to central scientific concepts but learners themselves cannot understand simply illustration in science textbooks. (Von Zeipel, 2014). Learners find it difficult to interpret and understand scientific concepts on their own even though these illustrations obviously points out a certain science concept. (Von Zeipel, 2014). Learners need guidance on how to interpret and fully analyze these illustrations for them to grasp its intended messages. It is important for educators also to know how to guide their students well especially in understanding different illustrations related to science concepts.

Working with illustration also can help an individual to hone their own skills in presenting data using images. (Madhusoodanan, 2016). These will aid educators in teaching scientific concepts without using textual presentations. They can impart knowledge with images only as an instructional material. A lack of knowledge on how to properly interpret visual language may hinder the proper interpretation of data (Pintó and Ametller, 2002). Thus, the role of educators in aiding learners to learn to understand visual representation and language is important.

Visual representations should be understood by learners at school and by educators during their in-service and pre-service years. Educators must also be aware that these images and representations are worth than a thousand words and effectively teaching how to interpret them to learners could unlock different possibilities in their learners (Pintó and Ametller, 2002).

Students somehow lack visual transparency when trying to explain certain concepts using illustrations. However, when they try to converse with people using their illustration, they tend to develop new concepts from it (Von Zeipel, 2014). Misuse of visual language can affect the interpretation of the image originally intended for (Pintó and Ametller, 2002).

The four immediate accessible points for practicing teachers to consider in teaching concepts with constructivist teaching: (a) recognizing what learners already know; (b) teach fewer concepts; (c) improve continuity across key stages and progression of the development of concepts; and, (d) acknowledge the diversity of learners.

Science educators need to look beyond the confines of cognitive psychology in developing pupils' understanding of scientific concepts (Wilson,2000)

Assessment for Learning is an effective way of actively involving students in their learning. Usually, the steps are. Initial self assessment is followed by peer questions and judgments and the focus is on the whole group rather than individual understanding with peer mentoring

To develop an assessment tool that adheres to the following Assessment Principles: (a) Manageable for both learners and teachers. (b) Give learners a range of ways to demonstrate their achievements. (c) Transparent ongoing process where learners' progress is monitored over time. (d) Use feedback to improve learning and reflect on the teaching and learning process.

Representational task helps the learners to organize and re-organize their thoughts about a certain concepts and pictures out the idea.

This alternative assessment tool is essential avenues of measuring the extent of understanding in the disciplinal content as alternative to traditional assessment methods (Lansangan, 2018).

Kozma (2003) proposed a conceptual structure showing representational competence into characteristic patterns of representational use at five stages or level which was the basis of the current study in constructing representational tasks for measuring understanding of the electron distribution of atoms.

Kozma considered representations when a person is asked to represent illustration of physical phenomena.

Level 1: *Representation as depiction*. This representation is an isomorphic, it is the iconic depiction of the phenomena at that point. The person can only provide illustration only basing from the physical features.

Level 2: *Early symbolic skills*. The person can provide illustrations based on its physical features added with symbolic elements to accommodate the limitations of the medium.

Level 3: *Syntactic use of formal representations.* This representation is an idiosyncratic, but may not be scientifically accurate. The person can provide illustrations of the phenomenon based on both observable physical features and the unobserved, underlying processes or entities.

Level 4: *Semantic use of formal representations.* This representation is both based on syntactic rules and meanings. The person correctly uses a formal symbol system to represent underlying, unobservable processes or entities. The person is also able in connecting different representations and or is able to transform a representation to another basing on the shared essence of the representations and features.

Level 5. *Reflective, rhetorical use of representations*. The person is able to provide one or various representations to explain the relationship of the physical properties and physical features and can use specific features of representations to allow the claim within the context. The person can select or construct the representation that is most appropriate for a certain situation and is able to explain which representation is more appropriate.

The representational task is an outcomes based assessment tool, allowing to access the learners perceptions on a certain topic through their representations.

The outcomes based education is an education theory that bases each part of the system as outcomes based, that by the end of the educational experience of the learners, each student should have achieved the goal. The representational task asks the learners to demonstrate what "they know and are able to do", pertaining to the topic.

Learners have different understanding of what an atom is. The most common definition is that it is composed of a dense nucleus composed of positive and negative charged particles. But also an atom is a part of a molecule that cannot be observed by merely doing experiments (Ayers, Par, &Nalewajski, 2005). Educators could gather understanding of learners regarding an atom by asking them to illustrate what they imagine of an atom, and they could add-up to their existing knowledge of the atom by the same means. Having illustrations as a means of explaining things could make learners learn what is beyond memorizing terms (Singh and Yaduvanshi, 2015).

A study on misconceptions of atoms (Papageorgiou, 2016) Main objective of a teaching/learning procedure is explanation of; (a) Properties of a substance and a number of its physical changes: *understanding of the behavior of the particles of microcosm rather than how they appear*. (b) Chemical phenomena: *understanding of the atom itself as identity and behavior, its differences from the other particles of the microcosm, is a fundamental precondition*.

Findings of the present work do not underestimate the importance of the atom as a fundamental identity and idea in general, but they rather specify the degree to which the knowledge relevant to the atom is associated the electron distribution in atoms.

Schulman, an expert science teacher, knows the difficulties students face and the misconceptions they develop, and knows how to tap prior knowledge while presenting new ideas so students can build new, correct understandings.

"Expert teachers have a firm understanding of their respective disciplines, knowledge of the conceptual barriers that students face in learning about the discipline, and knowledge of effective strategies for working with students. Teachers' knowledge of their disciplines provides a cognitive roadmap to guide their assignments to students, to gauge student progress, and to support the questions students ask."

2. Objectives of the Study

The representational task would help show the understanding of the participants on the electron distribution of atoms. The representational task would provide variety of understanding from various perspectives. This study aims to (1) qualitatively and quantitatively assess the understanding of the pre-service physical science teachers, (2) qualitatively and quantitatively assess the understanding of the in-service physical science teachers, and (3) gather insights about the understanding of the respondents.

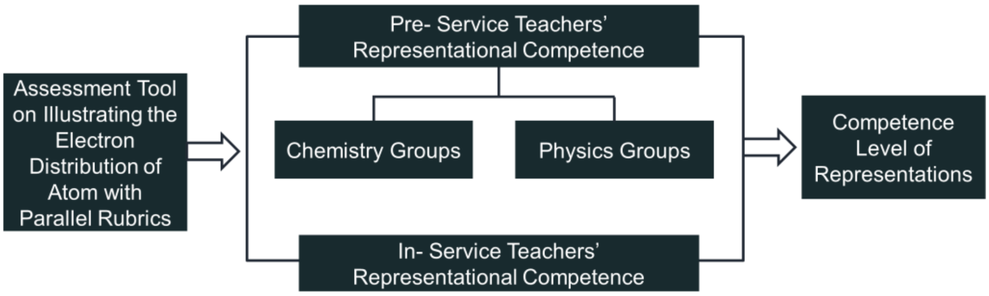

Figure 1: Research Paradigm of the Study

3. Research Methodology Research Design

This study used both qunatitative and qualitative research methods. In the qulaitative part, the use of the representational tasks with parallel rubrics indicates the understanding on the targeted chemistry concept. The chemistry concept concidered is based on the core of the discipline, the atom, specifically the understanding of the electron distribution of atoms.

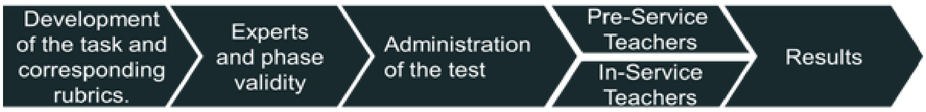

Figure 2: Flow of implementation of the study

Research Setting and Participant

The representational task with the parallel rubric was developed, validated and pilot tested to 30 pre-service physical sciences students and 30 in-service physicalteachers which are selected through purposive random sampling from Metro Manila. Both quantitative and qualitative data collected substantiate the conclusion that the task feasibly corresponds to the rubrics developed.

Research Instrument

Five (5) representational tasks were constructed and validated in order to determine the learners understating of the electron distribution of atom. The tasks allows the learners to illustrate and represent their own understanding about the indicated chemistry concept.

The development of the instrument started with the initial understanding of the task developers on the electron distribution of atoms. Both the content and the face of the assessment tool was validated by selected experts through a checklist adapted by the researchers and was revised as prescribed by the evaluators.

The following are the constructed representational tasks;

1) Illustrate the atomic structure of Oxygen $^{16}_{8}O$,
2) Illustrate the distribution of electrons in Oxygen $^{16}_{8}$O,
3) Illustrate the structure of the formation of an ion from element Sodium $^{23}_{11}$Na,
4) Illustrate the relationship of the electron configuration of $_{8}{}^{16}$O in its position in the Periodic Table,
5) Illustrate the relationship of atoms and periodic trends.

Analysis and Scoring

The assessment on the response of the participants' from the five (5) representational tasks that aims to understand the electron distribution of atoms is based on a scoring guide developed that is patterned from the representational competence level of Kozma's (2005). The evaluators included high school chemistry teachers and chemistry educators from higher learning institutions.

The rubrics used a five-point scale (1-5) where one (1) as the lowest level and five (5) as the highest level of understanding of the chemistry concept, this is to show the hierarchy of the understanding of the participants using representations. Hence, the level 1 corresponds to one point and so on. The indicators from the rubrics on each scale were provided as guide for the possible response of the participants.

4. Results and Discussion

The Understanding of Pre-Service Teachers

There are total of 30 pre-service teachers as respondents for the study, 15 students from the chemistry group and 15 students from the physics group.The gathered data helped the researchers to obtain certain observations regarding the representational task about the electron distribution of atoms.

Table 1: Summary of pre-service teachers' representational competence level

Task	*Frequency*					Total
	Level 1	Level 2	Level 3	Level 4	Level 5	
1) Illustrate the atomic structure of Oxygen $^{16}_{8}O$	7	2	16	3	0	28(2 no answer)
2) Illustrate the distribution of electrons in Oxygen $^{16}_{8}$O	5	13	8	2	1	29(1 no answer)
3) Illustrate the structure of the formation of an ion from element Sodium $^{23}_{11}$Na,	5	8	4	3	1	21 (9 no answers)
4) Illustrate the relationship of the electron configuration of $_{8}{}^{16}$O in its position in the Periodic Table.	9	2	2	0	3	16 (14 no answers)
5) Illustrate the relationship of the atoms and the periodic trends	5	8	7	4	1	25 (5 no answer)
Frequency of Competence Levels	31	33	37	12	6	119
Percent Distribution	26.1 %	27.7 %	31.1 %	10.1 %	5.0 %	100 %

The following are observed in every task;

Task 1: The respondents was able to write the distribution of particles in the oxygen atomic structure however some just indicated the electron and others have wrong distribution of particles. No one was able to obtain a level 5 representation.

Task 2: The respondent was able to illustrate the electron distribution of oxygen however some have incomplete and wrong distribution. One (1) was able to obtain a level 5 representation.

Task 3: The respondents may have found some difficulties in this task because only 21 were able to answer and 9 among the respondents were not able to answer. This is maybe because students lack idea about ions.

Task 4: Among all the tasks this item is considerably the most difficult because only 16 were able to answer and 14 was not able to answer. This may indicate that students may have lack idea about the essence of the electron configuration and its effect on the location of an element.

Task 5: The fifth representational task were found to be difficult as the task number four, this shows that the respondents has less understanding of the atoms and the periodic trends.

Comparing the Understanding of the Chemistry and Physics group

In comparing the two (2) sets of respondents, it was expected that the fourth year Chemistry student would exhibit better frequency of result than Physics students, however based on the gathered, it turns out that Physics students in fourth year had more understanding about the periodic table and atom.

Physics students turns out to have more numbers of students to gain level 5 in representational task but Chemistry also have more numbers of responses in difficult tasks such as in tasks 4. Both respondents form the Physical Sciences Department has exhibited average result in the representational tasks.

The Understanding of In-Service Teachers

There are total of 30 in-service teachers as respondents for the study that is teaching physical sciences in the secondary level. The teachers constructed more representations that are detailed in order to demonstrate higher level of learning in the targeted chemistry concept.

Teachers were able to realize the importance of giving and using competence levels of representations in distribution of electrons in the atom.

Table 2: Summary of in-service teachers' representational competence level

Task	*Frequency*					Total
	Level 1	Level 2	Level 3	Level 4	Level 5	
(1) Illustrate the atomic structure of Oxygen $^{16}_{8}O$	0	5	8	10	7	30
(2) Illustrate the distribution of electrons in Oxygen $^{16}_{8}\mathrm{O}$	1	2	5	8	14	30
(3) Illustrate the structure of the formation of an ion from element Sodium $^{23}_{11}\mathrm{Na}$,	1	3	4	12	10	30
(4) Illustrate the relationship of the electron configuration of $_{8}{}^{16}\mathrm{O}$ in its position in the Periodic Table.	2	4	6	11	9	30
(5) Illustrate the relationship of the atoms and the periodic trends	1	2	2	14	11	30
Frequency of Competence Levels	5	16	25	55	51	152
Percent Distribution	3.3 %	10.5 %	16.4 %	36.2 %	33.6 %	100 %

The following are observed in every task;

Task 1: The respondents was able to write the distribution of particles in the oxygen atomic structure and showed good level of understanding and achieving level four (4) and five (5).

Task 2: The respondent was able to illustrate the electron distribution of oxygen and most of the respondents obtained the highest score by showing a more detailed illustration of the electron distribution of atom.

Task 3: The respondents was able to illustrate the structure of the formation of an ion from element Sodium $^{23}_{11}\mathrm{Na}$, showed good level of understanding and achieving level four (4) and five (5).

Task 4: The respondents illustrated their knowledge of the periodic table and the relationship to the location of the element based on their electron configurations.

Task 5: The respondents found it easier because of the higher frequency on the level four (4) and five (5) compared to the first four tasks.

It was observed that the science teachers have sufficient knowledge of the topic, the electron distribution of the atom. However, it was also observed that the some of the teachers exhibited less knowledge of the concept, this could be implied from their personal profile that some of the in-service teacher respondents do not have a specialization in physical sciences (chemistry or physics).

5. Conclusion

This study provides information about how physical science pre-service teachers and physical science in-service teachers understands the electron distribution of atoms through representations with corresponding competencies and parallel rubrics.

The respondents of the study represents pre-service teachers that has a significant distribution of understanding at level 3 – *syntactic use of formal skills*, level 2 - *early symbolic skills*, and level 1 – *representation as depiction*, consecutively from highest. This generally shows that the representational competencies of the pre-service teachers is that they are able to provide illustrations on the basis of the physical features provided with symbols and some observable and unobservable entities or processes. However, this representational task also provided misconceptions of the respondents regarding the electron distribution of atoms, particular to tasks four (4) and five (5) where they do not have sufficient knowledge on the relationship of elements in its location on the periodic table and the relationship of the electron distribution of atoms to the periodic trends. Furthermore, this study also shows that there is no significant difference on the understanding of the electron distribution of atoms between the two groups of pre-service teachers, the chemistry group and the physics group.

The respondents of the study also represents in-service teachers that has a significant distribution of understanding at level 4 - *Semantic use of formal representations*, and level 5- *Reflective, rhetorical use of representations*, consecutively form highest. This generally shows that the representational competencies of the in-service teachers is that they are able to correctly use a formal symbol system to represent underlying, unobservable processes or entities. They are also able to provide one or various representations to explain the relationship of the physical properties and physical features and can use specific features of representations to allow the claim within the context.

Among the respondents' takeaway of the experience is about the importance of organizing and re-organizing their thoughts on the concepts and pictures out the idea, giving importance in checking and correcting misconceptions, measuring their level of understanding and reflecting on how to improve their understanding on the topic.

Subsequent presentation of the tasks makes learners to construct more detailed representations to demonstrate higher level of achievement/ learning. This type of assessment makes student conscious of their thinking and learning processes.Low achieving students tend to participate and misconceptions are corrected individually and mostly self-directed.

6. Recommendation

A longitudinal design would further determine the stability of the obtained information over time. Therefore, the results should be treated as exploratory, and not as conclusive, given the limited scope of this study.

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