JHS SCIENCE TEACHERS' PERSPECTIVES, PRACTICES, AND CHALLENGES IN TEACHING THE ATOMIC STRUCTURE

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Abstract

The concept of atomic structure is a difficult topic to discuss among students and has been one of the teachers' major concerns for many years. This study was conducted to determine the JHS (Junior High School) science teachers' perspectives, practices, and challenges in teaching atomic structure in selected public JHS. A survey method was employed, and the quantitative and qualitative results showed that the teacher-respondents had good perspectives, were proficient in the subject matter, and were eager to teach the concept properly. The use of visual aids/models, hand-outs/printed materials, and video lessons/presentations to teach atomic structure is the teachers' choice and is an invaluable learning material and tool in teaching the atomic structure to JHS students. The main challenges in teaching are the students' low interest and background and the lack of resources and training among teachers on the topic. There is a need for enhanced pedagogical tools, strategies, and skills, as well as training for teachers to support the atomic structure teaching and learning development and progress.

INTRODUCTION

The way science concepts are explained has long been a source of different studies and brought effects to the way teachers of physical sciences bring in and discuss ideas with the students (Geelan, 2020). It is imperative that students learn how to raise their basic understanding of baseline chemistry concepts (Salame, 2021). Chemistry as a major field involves abstract concepts that require visualization. Students find difficulty in conceptualizing ideas involving the atom, molecule, compound, and mixture. Added to this is the challenge of teaching the mechanism of how atoms form molecules, compounds, and other structures through bonding (Meydan, 2020). Knowledge of the atomic structure is an important basic concept needed to understand and explain all the other scientific concepts. Gradually and repeatedly, atomic structure is a topic that is given attention in many courses of study in which it is explained at different degrees of depth to correlate with other concepts. A well-understood concept of the atom, therefore, could provide the learners with a solid background to pursue a deeper understanding of our changing life, environment, and technological advancement.

A foundational and important concept in all disciplines of science is the nature of matter which is based upon the atomic theory. The atoms are considered the building blocks of matter, and an understanding of the basic concepts such as its structure and properties is essential for everything from the tiniest particle that makes up nature to the more advanced nanotechnology. From a historical perspective, it was mentioned that from the idea of Democritus of materialism based on the atomic nature of the world up to the quantum-based electron cloud model, the atomic structure is always and will always be a salient concept in chemistry. Atomic structure and model help make students understand various scientific theories by showing the theoretical structure of atoms through visual representations. However, students also experience difficulties and misconceptions concerning it (Park, 2006). It is therefore essential to look at how it is taught and learned.

In 2016, the Philippine Government through the Department of Education (DepEd) implemented the Enhanced Basic Education Curriculum or K-12 Curriculum and crafted the Curriculum Guide in Science (CGS) which serves as a guide for teachers. The CGS helps the teachers determine the essential information students need to know and the various standards students need to meet at the end of a year level. Under the CGS, concepts, and skills in various sciences including Life Sciences, Physics, Earth Sciences, and Chemistry are presented in a spiral progression approach or by increasing complexity. The result is a deeper understanding of the core concepts in science. In Chemistry, the atomic structure is introduced in Grade 8 Science where particles of matter and the structure of atoms are discussed. This is followed by Grade 9 science which primarily focuses on how atoms form molecules and the development of various atomic models (DepEd, 2016). Before the K-12 Program, there had already been a similar approach as reported by the SEI-DOST & UP NISMED (2011), The third and fourth-year level students of the previous curriculum or equivalent to the present students in Grades 9-10 were expected to have developed a deeper understanding of the concepts of atoms and molecules to describe and explain the structure and behavior of matter. Additionally, at present, the deeper and more detailed explanations of the atomic structure are taught in General Chemistry 1 and Physical Science subjects in Senior High School (SHS).

The learner-centered and advanced chemistry content of the K-12 framework is still hindered by several factors including its extensive, challenging, and unconcentrated content. The spiral progression approach involves more sophisticated and advanced chemistry which becomes a challenge to non-chemistry teachers who are handling chemistry subjects. In addition, chemistry teachers must also have a solid science background. Some components make it more challenging for teachers like the lack of science content on different teacher training programs and the need to self-study to provide accurate and quality instruction to the class (Orbe et al., 2018).

The best way to introduce the particulate nature of matter needs to be further studied at different grade levels and identify how the students' alternative conceptions about particles may be addressed (Chiu & Chung, 2013). Understandably, there is a degree of incoherence among students' mental models of the atomic structure. They exhibit variation in terms of complexity and abstractness. Although atom models can often be seen in different educational platforms and even social media, their understanding in scientific terms needs more analysis in classrooms since it is believed that students' knowledge particularly on the atomic structure is built basically in schools. A real problem may exist when there is a struggle for active learning among students. The students' unfamiliarity with needed science practices, struggle with uncertainty sans authoritative information, and additional effort in the construction of knowledge have been considered as sources of resistance to active learning (Owens et al., 2020).

There have been many strategies and tools developed for teaching the atomic structure. Some teachers use static pictures and diagrams of an atom such as virtual reality simulations and visual analogies of various atomic models and structures. For example, the use of foldable can enable students to keep all information about atoms in just a single piece of paper or place. Aside from this, paper-cutting activities can let students have a visualization of what an atom looks like. Hands-on activities on the other hand, like building their atomic model can help the students to be engaged and help them understand how each part of an atom is organized. Also, the use of multimedia including eye-catching videos can provide simple analogies for students to understand the lesson easily (Takarsh, 2020). Others use methods like role-playing in teaching atomic concepts that let students actively participate in the learning process. Also, the use of 3-Dimensional (3-D) graphics in teaching atoms, can allow students to experience what it is like "inside" an actual learning environment. However, despite these, it has been determined that still some students struggle to understand particulate ideas and find it hard to comprehend how the various subatomic particles interact (Netzell, 2015).

The teachers' efforts should focus on the concretization of science concepts like the atomic structure that appears abstract to students. Any introduction to new concepts, phenomena, or situations should be manipulated as a reorganizing process of pieces of knowledge (existing and new) and not as an issue concerning coherent mental models for atomic structure (Zarkadis et al., 2017). For instance, a study by Cheng (2018) identified that students rarely represented the role of electrons (from magnesium) in the formation of oxide ions, even when they used the atomic model. He suggested in constructing drawings, teachers should consider providing scaffolds to prompt students to consider the role of electrons in the reaction and their drawings. It was also suggested that teachers be sensitive about students' representations, and avoid dismissing these as mistakes. The teachers must be able to help students in distinguishing their representations consistent with the accepted model. These simply put forth the key role of the teacher in identifying the alternative conceptions and gaps in visual representations of the atom and its components. Thus, the teacher has sa greater responsibility of coming up with plausible solutions that will the aforementioned concerns on the learning and teaching of atomic structure.

Though the selection of an apt representation for the teaching and learning of the atomic structure is a challenge, careful attention to the teacher's preference on what to use for its representation needs to be placed. Since it has been identified that Bohr's model was considered the closest to physical reality, this model particularly that of the hydrogen atom, must be considered as an essential concept for learning the atomic structure using quantum mechanics (Malkawi et al., 2018). Likewise, the use of visual representation has been identified to endorse learning. For instance, the use of a virtual atomic structure laboratory can place students at the center of the learning process since it employs personalization, inquiry-based, and self-directed learning. Also, the use of multimedia and interactive activities together with the application of Information and Communication Technology (ICT) tools can make teaching the atomic structure more engaging, and encouraging, and can create an enjoyable learning environment, therefore, promoting a student-centered and more meaningful way of learning (Liwanag & Ramirez, 2019; Lynch & Ghergulescu, 2018). Providing enriching class activities can help in the comprehension of these abstract topics and increase lesson prominence. As stated, various computer software bringing visuals can be an effective tool in teaching atoms since students get to see what is presented (Temel & Özcan, 2020)

However, despite the foregoing enhancements in teaching and learning about atomic structure, challenges persist. For teaching, the challenge may not only be among in-service teachers but also the preservice teachers as well. They experience having difficulty in explaining lessons associated with it like that of the quantum numbers. For learning, students may find difficulty in learning topics about atoms since they find it abstract. On one hand, students studying quantum numbers and atoms have misconceptions since they do not have a detailed comprehension of them. (Temel & Özcan, 2020). It is therefore the aim of this study to determine the teachers' perspectives, practices, and challenges in teaching the atomic structure. Understanding how the teachers view this concept and bringing to the fore their practices and challenges in teaching will aid in developing more effective strategies for teaching the atomic structure. It is of value to note the recommendations of the teachers themselves in coming up with these strategies which they think will be helpful in their teaching.

METHODS

In this study, the researchers collected concurrently both quantitative and qualitative data. These were integrated to understand the JHS science teachers' perspectives and practices and their recommendations in teaching the atomic structure based on the challenges they have encouraged and ask for their recommendations using an e-survey form. The teacher's perspectives, practices, and challenges were determined quantitatively. Qualitatively, the inclusion of open-ended questions was used to determine how the teaching of the atomic structure could be improved by exploring the teachers' recommendations based on their experiences. The resulting qualitative themes were transformed into counts and presented with descriptive quantitative data (Creswell, 2014).

Before data collection, approvals from school heads were sought by the researchers. Upon approval, the e-survey form was sent to the teacher-respondents. Of the different JHSs in Region 3, a total of 99 teachers responded to the e-survey form. Data collection lasted for two months. For the collected quantitative data, mean and standard deviation were determined while thematic analysis was employed for the responses to the open-ended questions.

Also, in the questionnaire, the respondents were asked about their teaching backgrounds. These included their age range, position in school, years of teaching in JHS, and years of teaching science in JHS. Particularly, the type of public high school they are teaching in was also asked and considered in the questionnaire. The 99 teachers worked in 5 different public JHSs, hold varying school positions, and were distributed from novice to very long-tenured. All these data represented the diverse distribution of the teacher-respondents for the data collected (Table 1).

Table 1

Profile of Teacher-Respondents (N = 99)

Age (Years)	*f*	Position	*f*	School Classification	*f*	Years Teaching in JHS	*f*	Years Teaching Science in JHS	*f*
20-30	29	Faculty (Teacher I-III)	85	National High School	78	0-5	33	0-5	34
31-40	28	Head Teacher	1	Barangay High School	6	6-10	16	6-10	17
41-50	24	Master Teacher	13	Technical-Vocation High School	10	11-15	22	11-15	22
51-60	18	Principal/OIC	0	Science High School	2	16-20	9	16-20	9
61-above	0			City High School	3	21-25	8	21-25	7
						26-30	7	26-30	7
						31-35	3	31-35	2
						36-40	1	36-40	1

RESULTS AND DISCUSSIONS

Table 2 provides the descriptive measures of the teachers' perspectives on teaching the atomic structure. There are eight items and all the data show low variation concerning the mean. This implies that a high percentage of the respondents agree and have a good perspective on teaching the atomic structure. The teacher's perspective directly impacts students' emotions and learning. Thus, this positive perspective can help improve the academic achievement of students (Desautels, 2014). Notably, most of the teacher-respondents are familiar, confident, and knowledgeable of the atomic models and structures. These behaviors suggest that the surveyed teachers are adept at the subject matter and could teach the concept properly. Moreover, the conceptual understanding of a teacher and knowledge is critically important for students. If a teacher demonstrates limited knowledge and understanding of a particular topic, students will struggle to understand the topic hinder students' development (Walshaw, 2012).

Table 2
Descriptive Measures of the Teachers' Perspectives on Teaching Atomic Structure (N=99)

Item	Mean	SD	Descriptive Interpretation
1. I have no difficulty in teaching electron configurations	3.86	0.98	*Agree*
2. I enjoy teaching quantum numbers.	3.66	1.06	*Agree*
3. I am familiar with the different atomic models	4.13	0.90	*Agree*
4. I am confident to teach the different atomic models	4.01	0.87	*Agree*
5. The learning tools/materials that I am using are effective for teaching and learning atomic structure	3.80	0.78	*Agree*
6. My teaching strategies/techniques in teaching atomic structure are effective.	3.83	0.77	*Agree*
7. I am knowledgeable of the atomic structure concepts	4.01	0.83	*Agree*
8. I find the concept of atomic structure not abstract.	3.61	0.99	*Agree*
Total Mean	**3.86**		

The use of different tools and teaching strategies greatly improves the teaching practices in chemistry teaching as reviewed. In this study, the use of visual aids/models, hand-outs/printed materials, and video lessons/presentations to teach atomic structure is the teachers' choice and is invaluable learning material in teaching the atomic structure (Table 3). The use of visual aids as a method of teaching helps stimulate students' thinking, improve the learning environment, and enhance students' understanding of the topic (Shabiralyani et al., 2015). Simulations, games, and interactive online tools are also being used sometimes, and teachers may have resorted to these aids whenever available or applicable. Lecture/discussion and cooperative learning are found to be the most important strategies or teaching techniques according to the teacher-respondents. As pointed out by Bala et al. (2017), the lecture method can help improve academic achievement by providing students with a more conducive environment, allowing them to move at their own pace, helping them organize content, and clear their thoughts. Other strategies are also being implemented by the teachers sometimes, such as storytelling, mnemonics, infographics, and concept maps. These mostly support strategies to improve teaching-learning activities.

Table 3

Descriptive Measures of the Teachers' Practices in Teaching Atomic Structure (N=99)

Item	Mean	SD	Descriptive Interpretation
Learning Tools/Materials Used	**2.26**		
1.Visual Aids/Models	2.67	0.53	*Always*
2. Hand-outs/Printed Materials	2.58	0.59	*Always*
3. Video Lessons/Presentations	2.57	0.56	*Always*
4. Simulations	2.08	0.61	*Sometimes*
5. Games (ex. Online Games)	2.01	0.63	*Sometimes*
6. Interactive Online (Jamboard)	1.96	0.68	*Sometimes*
7. Others	1.95	0.66	*Sometimes*
Teaching Techniques/Strategies Implemented	**2.18**		
1.Mnemonics	2.43	0.69	*Sometimes*
2. Songs/poems	2.03	0.70	*Sometimes*
3. Story Telling	1.86	0.62	*Sometimes*
4. Lecture Discussion	2.75	0.46	*Always*
5. Cutouts/Foldable/Collage	2.11	0.69	*Sometimes*
6. Mind Maps/Concept Maps/Fishbone Map	2.41	0.63	*Sometimes*
7. Infographics/Posters	2.24	0.63	*Sometimes*
8. Interactive Games/Competitive Games	2.07	0.68	*Sometimes*
9.Cooperative Learning	2.61	0.53	*Always*
10. Reflective Journal	1.98	0.67	*Sometimes*
11. Others	1.83	0.70	*Sometimes*

Despite the positive perspectives and applicable tools and strategies, teachers still find many challenges and difficulties in teaching the atomic structure (Table 4). Of the six (6) concerns under this category, all of the teacher-respondents have neutral responses to the statements on the listed teachers' challenges in teaching atomic structure. The inadequacy of textbooks and guides, as well as teacher training programs, are the major important issues in public JHS. The inadequacy of textbooks was found to be one of the complex problems or issues in the field of science education (Anderman et al., 2012). In an assessment of the least mastered content (LMC) for science in the K-12 curriculum, Cajimat et al.(2020) stated that there is a weakening in learning content in its different areas, including chemistry, as the grade level increases. Thus, the recommendations for similar concerns relating to the provision of teachers' training and workshops for both assessment and content, specific instructional materials, and team teaching. As for the rest of the challenges, the difficulties in teaching students due to their lack of good background, familiarity, and understanding of the basic concept of atomic structure, can also be improved from the aforementioned recommendations.

Table 4

Descriptive Measures of the Teachers' Challenges in Teaching Atomic Structure (N=99)

Item	Mean	SD	Descriptive Interpretation
1. There is inadequacy in the number of textbooks and guides in teaching the concepts of atomic structure.	3.36	0.97	*Neutral*
2. The students are not familiar with the basic concepts of atomic structure.	3.32	1.02	*Neutral*
3. The students do not have concrete ideas of what an atom is.	3.00	0.98	*Neutral*
4. There is inadequacy in teacher training programs for teaching the concepts of atomic structure.	3.26	1.04	*Neutral*
5. Students find the concepts of the atomic structure too abstract.	3.30	0.87	*Neutral*
6. I am having trouble focusing and teaching atomic structure because of insufficient time and resources.	2.96	1.07	*Neutral*
Total Mean	**3.20**		

In the light of teachers' views on the significance of students' understanding of the atomic structure in understanding other concepts in chemistry, the majority of the teachers have identified it as a foundational concept. They are cognizant of the importance of students' familiarity and knowledge of its connection to other concepts in chemistry. The abstractness and complexity of the concept of atomic structure have been revealed from the provided responses relating to its difficulty and failure to see concreteness in examples. Views have also been expressed on the pedagogical challenge of making students appreciate the concept. Likewise, some teacher-respondents have identified the necessity for different skills and strategies to be employed in making the students understand the concept. Lastly, many teacher-respondents have acknowledged that a student's attitude is significant in learning the concept. As has been identified, having a positive attitude is associated with engagement in chemistry learning (Ross et al., 2020).

Table 5

Teachers' Views on the Significance of Students' Understanding of the Atomic Structure

No.	Theme	Frequency	Sample Quotes
1	**Foundational Concept**	55	*"Understanding atomic structure would mean understanding the behavior of matter"* *"Understanding the atomic structure is like going back to the ABCs. Atomic structure is one of the fundamental concepts needed to understand chemistry. From various lessons such as Bonds, Periodicity, and a lot more, these need basic understanding of the atomic concept"* *"The basic concept of the atomic structure would lead learners to better understand reactivity and behavior of elements and compounds"* *"It is very important that students have background so that they will understand other concepts"* *"If learners know/understand the atomic structure, then it is easy for them to understand the chemical characteristics, behavior of atoms especially in the formation of compounds"* *"Knowledge about atomic structure helps students to think deeper about the matter that constitutes the concepts in chemistry"*
2	**Abstract and Complex**	3	*"For them it is complicated"* *"The students sometimes are having difficulty in understanding the atomic structure because they are used to see the concrete example of an object."* *"They have difficulties in identifying the structures of the atom mostly in getting the mass of the atom and etc."*
3	Requires Skills **and** Strategies	12	*"Concrete examples and relate this to their daily life"* *"As teachers we need to be more creative to teach atomic structure to students to catch their attention"* *"Know the strategy to be used"*
4	**Needs for Positive Attitude**	10	*"Their lack of interest in the subject matter"* *"The students' attitude in learning in general"* *"Students are not aware and interested about the importance of studying atomic structure"*

Note: A total of 19 teacher-respondents opted not to answer the question "What are your views regarding the significance of students' understanding of the atomic structure in understanding other concepts in chemistry?"

The teacher-respondents recommended that the teaching of atomic structure have to be simplified and concretized to the student's level of understanding.

Introducing atomic theory to students can be a challenge since they struggle to deal with abstract and microscopic concepts like atoms and molecules (Haeusler & Donovan, 2020). The teachers recommended simplification of the concept by using simple terminologies fit to their level and its concretization by using real-life examples or applications. Another recommendation is pedagogical enhancement. The majority of the teacher-respondents are in agreement with improving teaching atomic structure by applying differentiated teaching strategies to acquire knowledge (Boʻriboyev,2023), providing more practices and problems, encouraging students' engagement, and most especially having teacher training. The provision of learning materials is also another recommendation. The teachers have identified the learning materials in the form of models, references, modules, and those that use technology like simulations, games, and video presentations of lessons. Especially with the use of technology like simulations in introducing atomic structure, has been known to enhance learning among students by linking the macroscopic world with the submicroscopic component of chemistry and the submicroscopic component with the atomic structure and orbital diagrams (Maksimenko et al., 2021).

Table 6

Teachers' Recommendations on How to Improve the Teaching of Atomic Structure

Theme	Frequency	Sample Quotes
Simplification and Concretization	34	*"Have more concrete evidence, facts, and ideas about atomic structure to have more understanding about it."* *"Provide students real-life examples and activities to improve their critical thinking and scientific knowledge and skills in atomic structure."* *"Connect these topics to real-life experiences and how it makes a significant importance to everyday life."* *"The use of timely and simple examples for the lesson not to be too abstract"* *"Use familiar words and describe the lessons according to their level"*
Pedagogical Enhancement	46	*"Atomic structure is abstract, that's why it is not easy for students to understand and learn it. I think it would be best understood if the teacher will use simulation, video lessons, and more performance tasks to be given to the students for them to have firsthand experience on how to construct the atomic structure."* *"Provide activities that are enjoyable and easy."* *"It would be helpful if students will be involved and engaged, allowing them for a differentiation learning in the classroom. Also let the learners conduct their investigations, demonstrate their understanding of ideas, and defend their work."* *"Teachers should not give up and continue using innovative resources to teach it."*

Table 6

Teachers' Recommendations on How to Improve the Teaching of Atomic Structure-Continued

Theme	Frequency	Sample Quotes
		"There should be enough and appropriate Teacher Training Programs (TTP) that will cater to the needs of teachers when it comes to understanding atomic structure even deeper. TTP is necessary for making sure that teachers are equipped, prepared, and knowledgeable"
		"Provide more differentiated activities for atomic structure and be creative in your teaching style."
		"Attending webinars of teachers related to the subject matter as well as teaching techniques will surely improve teachers' teaching of atomic structure."
Provision of Learning Resources	19	*"More visual presentation to be given for the students to become more interested"*
		"Provide ICT tools in schools that can be used by teachers to effectively teach the lesson"
		" Models of the atomic structure and simulations may enhance learners' understanding of this concept"
		"More atomic models and videos and hands-on activities for students should be provided including the materials, manuals, etc."
		"Adequate supply of books and teaching materials about the topic is important"
		"It is advisable to use diagrams, simulations, models or anything that can help the learners to visualize atomic structure"

CONCLUSION AND RECOMMENDATIONS

The teaching of atomic structure has always been a challenge among JHS science teachers. However, they have positive perspectives on teaching the atomic structure. They commonly utilize in their teaching the learning tools/materials that are mostly for visual representations. As has been placed in different studies, visualizations and models such as drawings can support learning (Hanson, 2017). They also commonly employ lecture methods and cooperative learning as their teaching techniques or strategies. There was a recommendation for the use of differentiated teaching strategies in teaching the atomic structure.

Moreover, knowing the significance of learning the atomic structure, the teachers are mostly challenged by the student's background knowledge, skills, and attitudes. What appeared to students as abstractness and complexity of the atomic structure was another challenge. As part of the objective of this study, recommendations on how the teaching of the atomic structure could be enhanced were solicited from the teachers themselves. Recommendations were the simplification and concretization of the topic, a well-thought-of use and development of different strategies, and provision of assistance in terms of learning resources and training programs for teachers. More so, in the pre-service training of science teachers, there needs to be a focus on the application of differentiated instruction (Moosa, 2019) to augment students' learning of the atomic structure.

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