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# Incorporating Technology on a Chemistry Curriculum Material for Molecular Geometry

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**Abstract**

This paper aims to develop a curriculum material for science that is responsive to student's and teacher's feedback, societal demands and national goals. This study utilized input-process-output model of material development. Baseline evaluation of the needs, resources, goal alignment, and assessment of current curriculum involving Grade 9 students and teachers of a public high school in Bay, Laguna served as basis for the development of the curriculum material. The developed curriculum material features technology integration like audio-video clips, digital applications, hands-on activities encouraging improvisation of materials and community simulation, and concrete representations of abstract concepts to enhance student learning experience. Using the module, students were made to answer practice problems and exercises independently. The student involvement index, communication index, and Fry's readability index of the module was determined. The updated curriculum material was found to be useful to both the students and teachers.

***Keywords:*** curriculum development; molecular geometry; technology integration.

## 1. Introduction

### *1.1. Background of the study*

The past decade has seen the rapid development of internet as a medium of communication wherein industries have utilized it to create smarter systems through cyber-physical supports.

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Especially, Industry 4.0 initiates and catalyzes the birth of Education 4.0. This new era in education focuses on innovation and value creation, school ecosystem where students, teachers, and technological devices are intricately related, curriculum being transdisciplinary, and the target output of students are innovations [1]. Particularly, the mode of delivering the classroom instruction has evolved towards enhancing the pedagogy by incorporating technological skills. For this reason, digitized pedagogy has captured the attention of the educators and other policy makers in the continuous educational development. With this, curriculum developers consider technology integration as a key instrument in making innovative education. The Philippine educational system has undergone a number of curriculum reforms, with the implementation of the K-12 program being the latest. These reforms made the Philippine educational system more responsive to global demands by equipping Filipino students with 21$^{st}$ century skills [2]. Furthermore, the government recognizes the empirical role of education is nation building. In this light, this research examined the developed curriculum material designed for Grade 9 chemistry. Particularly, in this study, the researchers envisioned technology as a crucial part in making relevant curriculum to the 21$^{st}$ century classrooms.

### *1.2. Technology Integration in Education*

A number of researches has examined the integration of technology in education. The information and communication technology (ICT) are considered as means for the teachers to reach the instructional objectives. The mode of delivering classroom instruction has evolved in terms of the use of digital technologies and handheld gadgets [3]. The integration of information and communication technology is fast becoming a key instrument in enhancing learning. A considerable number of researches have reported that technology plays an essential role in promoting student-centered learning, improving learning process and exposing students in authentic learning. It can stimulate students' motivation and engagement by providing avenues to interact with the content and opportunities to have a control over the learning process [4,5,6]. Many has successfully blended pedagogical skills and technological skills in creating an ecosystem inside the classroom that involves the use of multimedia-based instructional materials, which are composed of graphics, video, and animations. From this, it can be inferred that technological educational tools are able to provide multiple modalities of learning that may contribute to better understanding and retention of learning. Moreover, these interactive features explain the findings that technological educational tools contributed to the improvement of the cognitive processing skills of the students as well as their attitude towards learning [4,7] Despite the significance and affordance provided by technology in education, many are still struggling on how to innovate teaching strategies which integrate technology [8,9]. Moreover, educators should be reminded that the use of technology in education should go beyond assisting the teachers, it should be seamlessly integrated as part of the teaching and learning process. Students should be engaged in learning with and through technology together with their peers. Technology coupled with appropriate teaching strategies could promote an optimum learning environment [9,10]. Truly, ICT integration can be considered as a way to develop the skills needed to meet the standards of global education.

### *1.3. 21$^{st}$ Century Learning*

The Partnership for 21$^{st}$ Century Skills (P21) regarded integration of technology as one of the tools to promote an innovative learning environment that could facilitate the development of 21$^{st}$ century learning skills [10].

Transforming traditional teacher-centered classroom to student-centered classroom is our first step to being closer to 21st century classroom [8]. The teaching strategies of the 21st century classroom promote the teaching and inculcation of the 4Cs: collaboration, critical thinking and problem solving, communication, and creativity and innovation (National Education Association, 2019). The 4Cs are believed to prepare our students for global citizenship and workforce. That is, citizenship and employment in a society with high levels of information and technological literacy. The National Education Association in partnership with other national organizations, enumerated various ways of putting to life the 4Cs in classrooms around the world [11]. To mention a few, scientific investigations and researches promote critical thinking and problem solving. Conducting and documenting interviews are good practice of communication and collaboration. There are available digital tools where students can create and design prototypes or plans for different scientific disciplines. Twenty first century teachers should now be challenging students with real life problems rather than laying down facts and content during lectures. These strategies foster the transformation of students to become producers of knowledge not just passive receivers as well as students who are more open to flexible learning spaces and seeks the transfer of learning in daily life. In this Education 4.0 era, where ideas are just accessible through our fingertips, the challenge is how to make sense of these information and translate it to a pedagogical strategy that is suitably crafted to the 21st century learners. Indeed, the current education landscape needs to be revitalized as a response to the fast-paced globalized education. Recent studies show how technology integration has positively influenced learning in terms of student achievement and learning attitudes. However, there has been few researches that analyzes a curriculum material development that focuses on molecular geometry in chemistry. This topic is considered as one of the foundations in understanding the properties and reactivity of substances. Students are having difficulty in the said topic especially that this topic is observed at the molecular level. The incorporation of technology facilitates better visualization of this concept, hence, reducing the abstractness of ideas. This study of curriculum material development will serve as model to educators on how be updated with trends in educational technology, be within the capabilities of the students, and be aligned with the institution's mission and vision. These factors, among others, should be carefully considered in deciding for a curriculum change and how this change takes place. Equally important to note, changes in the curriculum can be brought about by students' and teachers' feedback as well as content and structure evaluation of the learning materials [12]. As laid down in the book *Contemporary Issues in Curriculum*, curriculum designers are guided by their philosophies whenever organizing and implementing curriculums [13]. With the students and teachers as the end users of curriculum materials, this study aims to use the feedback of students and teachers on the current Science 9 curriculum and review of national and institutional goals in restructuring a curriculum material for Science 9 Molecular Geometry topic. It is believed that the involvement of students and teachers in developing the curriculum material will make the material more relevant and useful. Further, it attempts to re-shape the use of technology in the classroom.

### *1.4. Purpose of the Research*

The main purpose of this study is to develop a curriculum material which uses technology as an aid in delivering content and simulation of models for molecular geometry chemistry topics. Specifically, the developed curriculum material aims to:

1. Design a curriculum material that could address the difficulty of students in understanding and applying molecular geometry;

2. Develop laboratory activities that could help teacher and students to make molecular geometry lesson an interesting topic;

3. Validate the designed curriculum material on molecular geometry that utilized improvised materials; and

4. Evaluate the quality of the design through teachers' feedback and the effects of the developed curriculum material on molecular geometry to students' learning.

## 2. Methodology

### *2.1. Research Design*

The present study utilized the input-process-output model of material development. The study is divided into three parts: preparation, writing, and formative evaluation stage. A baseline study through survey and interviews with Grade 9 students and science teachers was conducted to determine their perceptions regarding the implementation and content of the current science curriculum. Afterwards, curriculum material for Molecular Geometry topic was outlined and developed based on the baseline evaluation. The writing stage included the writing of the content, lay-out of the module as well as the selection of illustrations, videos and other supplementary materials. The developed curriculum material was content validated and evaluated by teachers and students. The result of the formative evaluation of the curriculum material dictates the revisions to be made to improve the curriculum material.

### *2.2. Participants*

The participants of this study were Grade 9 high school students and science teachers of a science-oriented public high school in Bay, Laguna. In the preparation stage, there were about 30 students and 4 science teachers who were interviewed to establish the baseline evaluation. Moreover, 65 Grade 9 high school students participated in the evaluation of the developed curriculum material.

### *2.3. Instruments*

The developed curriculum material was developed and evaluated in terms of Fry's readability and Student Involvement Index. Moreover, a researcher-made, composed of 15-item four-point scale, was constructed in order to evaluate the validity of the module in terms of content and accuracy, alignment with the school's science program, originality and innovations, and clarity. The instrument's Cronbach alpha is 0.822 which indicated a high reliability of the instrument.

### *2.4. Data Collection*

The data collection activities done in the study are described below. It is subdivided into three parts corresponding to the Input-Process-Output model.

*Stage 1-Preparation Stage (Input)*

During the input stage, a baseline evaluation was conducted to the present science curriculum, resources, and challenges. This facilitated the review the areas of science curriculum needing improvement. The evaluation was participated in by the science teachers and selected Grade 9 junior high school students.

*Stage 2- Writing Stage (Process)*

The process stage of this research involves the writing of the curriculum material based on the results of the baseline evaluation. After identifying the topics which the students and teachers find challenging, the module was developed based on the reported difficulty of science teachers. The lessons and activities are designed to help make abstract lessons more interesting through inclusion of real-life applications of topics, hands-on activities, and collaborative learning. Also, the developed module incorporates improvisation of materials as well as seamless integration of different fields of science. There are salient features of the module that are designed to sustain the interest of the students and to guide them in organizing their thoughts about the topic. The module is organized into sub-topics. The sub-topics in the module are introduced using an intriguing science principle which supports the discussion. Afterwards, activities are integrated throughout the text. Subsequently, there are several call-outs which indicated specific learning episodes. For example, star call-outs are inserted within the activity to give reminders and tips in doing the activity. On the other hand, a smart bulb emphasizes important points in the text. Moreover, there are think outside the box questions posted at the end of each sub-topic that serve as a quick check of student understanding of the text. The module ends with a summary labelled as Chem Collection then a summative test entitled as Now It's Your Turn. Additionally, the developed module also comes with a Teacher's Guide which can help teachers in the enrichment of the content. Figure 1 shows the different parts and features of the developed material.

*Stage 3 - Formative Evaluation and Validation (Output)*

Two levels of formative evaluation were implemented in the developed curriculum material. First, the internal formative evaluation serves as internal review of the writer of the first draft of the module wherein was further subdivided into two parts, namely: student involvement index (SII) and readability index. For instance, the inclusion of activities helped increase the SII of the module. SII can be improved by increasing the number of questions requiring students to analyze data and be an active reader. This can be done by including more exercises and practice problems in the module. On the other hand, Fry's readability index was used to determine the if the material fit to the target Grade level of student users. Revisions were made based on the results of this evaluation stage before proceeding to the try-out stage. Meanwhile, the external formative evaluation was participated in by four science teachers teaching chemistry. All teachers were graduates of University of the Philippines Los Banos. Three of these evaluators finished BS Mathematics and Science Teaching, who are pursuing their master's degree at University of the Philippines Diliman and De La Salle University. Moreover, a 15-item four-point scale researcher-made test was used to check the validity of the module in terms of content and accuracy, alignment with the school's science program/objectives, originality and innovations, and clarity. Furthermore, the developed material was also subjected to feedback-based readability or communication index. This index is based on the number of unclear words and number of students who reported those words during the try-out stage of the developed material.

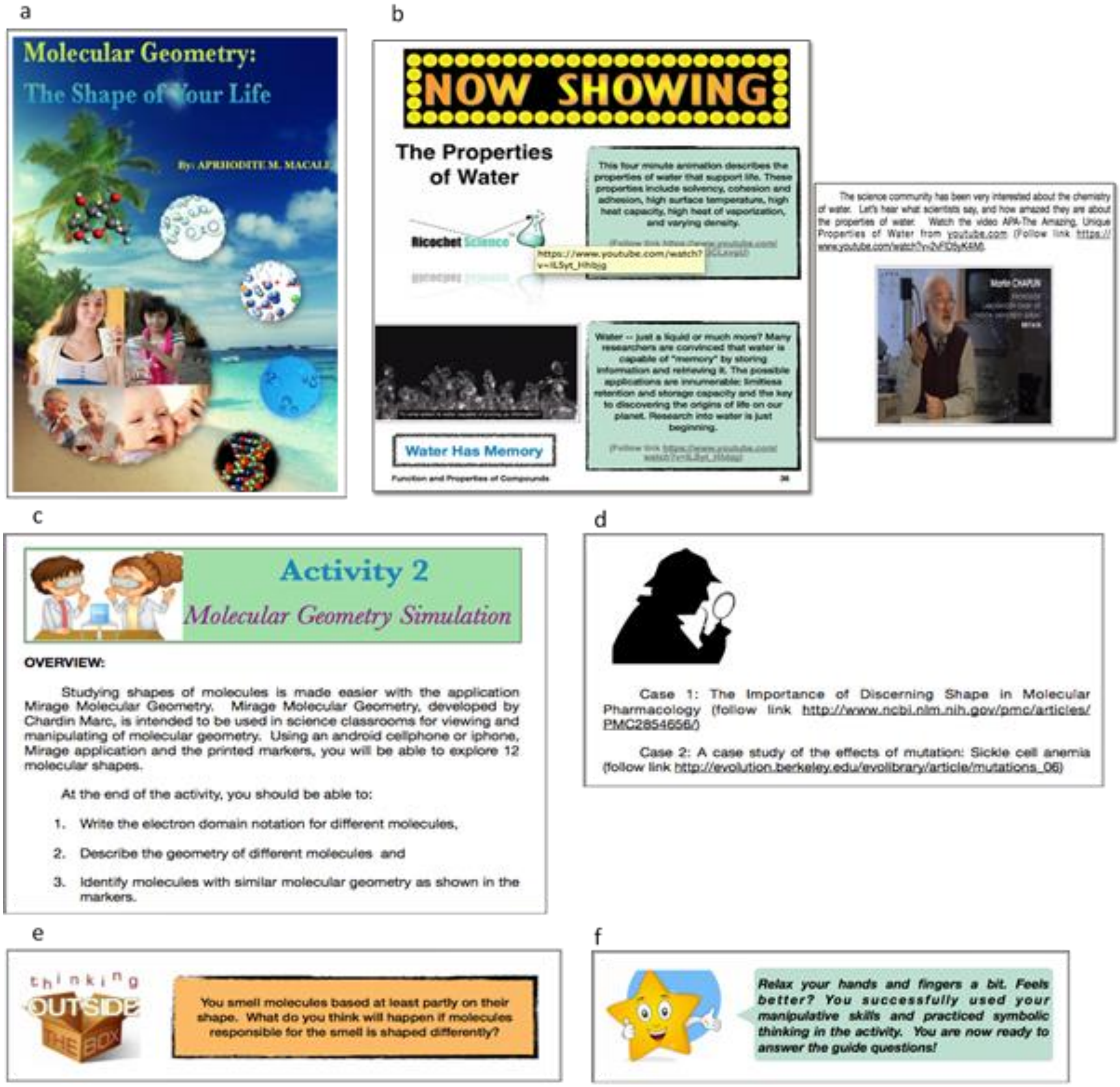


**Figure 1:** Salient features of the module *Molecular Geometry: The Shape of Your Life*. a) cover page,b) video links, c) activity incorporating the android/apple application Mirage, d) Mystery cases for real life application, e) thinking outside the box and f) star call-out.

### *2.5. Data Analysis*

Due to the nature of the study, descriptive statistics were utilized to analyze the quantitative results of the study. Additionally, Cronbach's alpha was used to establish the reliability of the responses in the instrument. Furthermore, the synthesis of interviews conducted to teachers and student participants were used to gauge the acceptability and determine necessary revisions that should be done to improve the material. Lastly, corresponding textual evaluation of the material was used to compute the readability, communication, and student involvement indexes.

## 3. Results and Discussion

This section presents the results of the three (3) stages of material development used in this study. Furthermore, it is important to take note that each stage of the material development corresponds to specific objective of the study. The preparation stage (first stage) answers the way the learning module is designed based on the baseline evaluation that takes into consideration the existing curriculum and concerns obtained from initial interviews. Likewise, the writing stage (second stage) addresses the second objective that has something to do with the development of the curriculum material for molecular geometry lesson in chemistry. Lastly, the evaluation and validation stage (third stage) are designed to achieve the third and fourth objectives which involves the validation of the developed curriculum material and the evaluation of the quality of the learning material, respectively.

### *3.1. Preparation stage*

The analysis of the events that happened in the preparation stage is subdivided into three parts. These include sections about the curriculum, teachers, and students. Analyzing the curriculum as well as the feedbacks of the teachers and students were beneficial in this research because it facilitated the mapping of the current status quo of the education. Eventually, this served as the backbones for the considerations during the development of the learning material.

*The Curriculum*

Baseline evaluation of the science curriculum revealed that the science curriculum of the school, where the study was implemented, meets the minimum competencies set in the K-12 program of the Department of Education. With its vision to be “an academically excellent science-oriented secondary educational institution”, the curriculum is made more advanced to become at par with the science high school curriculums. Focusing on the school’s curriculum and learning facilities, it can be observed that the enriched content of the curriculum enables the school to be competitive with neighboring science high schools. On the other hand, the laboratory facility and resources of the school is a work in progress. In fact, the limited laboratory facility and resources is really one of the pressing identified concerns in science education in the country [14,15]. For instance, in provincial areas, there is only one in every 10 schools has science laboratory facilities. On the other hand, urban areas, three in every 10 schools has science laboratory facilities [14]

*Teachers*

The science faculty are pursuing graduate and post-graduate studies in the field of science teaching. Despite the competencies and passion of the science teachers, a number of challenges are still to be hurdled. The ever-growing gap between generations has challenged teachers; first, to make the traditional sit-down lectures more interesting and second, to hold that interest until the end of the lesson. Additionally, teachers are challenged to translate abstract scientific concepts in a language easily understood by the students. Some teachers utilize alternative means to perform laboratory activities through the integration of simulations, animations, and other multimedia-based instructional materials [15]. Aside from this, there are still other identified challenges in teaching sciences such as limited instructional and laboratory resources that are considered as future turning points in the school's science program [16].

*Students*

The astringent admission policy of the school has provided a good pool of academically competent students. However, as reported by the science teachers, not all students are inclined to science. They observed that students become more attentive when they are tasked to design and fabricate materials and equipment. Several studies have emphasized that students are more motivated to learn if they are engaged in hands-on activities and exposed in learning environment that allows them to share their ideas and learning experiences [7,17]. To further determine the perceptions of the students on different learning objects, the students were asked to rank how different materials and activities in class help them understand and apply science concepts. The average ranking of each material/activity is presented in Table 1.

**Table 1:** Ranking of different materials/activity in aiding students to understand and apply science concepts.

| Activity/Material | Helps in Understanding Science | Helps in Applying Science |
|---|---|---|
| Assignments | 4.9 | 4.4 |
| Books | 4.2 | 4.6 |
| Experiments | 3.5 | 2.0 |
| Drills | 3.4 | 2.3 |
| Lectures | 1.5 | 3.8 |
| Online Resources | 3.7 | 3.9 |

*Note:* Rank 1 being the most helpful.

Based on the given table, lectures are considered by the students as the most helpful in understanding science concepts. This commends teachers on giving clear and in-depth explanations of science concepts, immediate feedbacks as well as effective visuals, presentations, and activities in class. The learning activities and instructional materials used to enhance the lecture are supported by several literature. For instance, illustrations, diagrams, and models are useful visuals incorporated in the lesson help concretize abstract ideas [18]. These multi-media based instructional materials provide varied channels of encoding of information through visual, auditory, verbal and nonverbal elements that collectively stimulated active brain processing [4,6,7]. Furthermore, the activities in the lecture engaged students in cooperative learning allowing them to develop collaboration and critical thinking skills [19]. Furthermore, looking closely at the results on application of science concepts, experiments rank first. Experiments promote experiential learning and foster creativity in performing different laboratory activities. The laboratory activities allow the students to see how the science concepts work and apply to daily life. Most importantly, through experiments, students were able to reflect on why they are studying science and appreciate it more. Moreover, during the preparation stage, the researchers were also able to identify the topics which seem to be challenging to understand by the students. For the topics they find difficult, the students reported the mathematical computations in kinematics and stoichiometry. Similarly, students find topics which require memorization like taxonomy and nomenclature of organic compounds, periodic properties of elements, electronic configuration, stoichiometry, nomenclature of organic compounds and molecular geometry.

### *3.2. Writing Stage*

This study focused on the development of a module for the topic in molecular geometry. In the baseline evaluation, 30% of the students interviewed have expressed difficulty in understanding molecular geometry.

**Table 2:** Task analysis for the module *Molecular Geometry: The Shape of Your Life.*

| Objective | Strategy |
|---|---|
| Demonstrate (VSEPR) using balloons | [1]Group Activity<br>Students will inflate balloons. They will demonstrate VSEPR Using the balloons as the electron clouds. |
| Predict the 3-dimensional shapes of simple molecules based on VSEPR theory | [2]Class Exploration<br>Students will construct molecular models representing different numbers of electron cloud domains |
| Simulate molecular geometry using android tablet application | [3]Technology Integration<br>Students will explore the shapes of molecules using android tablets with downloaded app and printed Mirage markers. |
| Construct clay-wood and human molecular models | [4]Group Activity During the Lab Period<br>The activity will be divided into two parts. The first part will be indoor. Students will prepare the materials and construct molecular models using engraved woods, sticks and clay.<br>The second part will be outdoor. Students will construct human molecular models in the field or gym. |
| Describe some physical properties of molecules based on their molecular geometry | [5]Video Presentation<br>Students will examine the unique properties of water through video streaming and how its properties are related to its bent molecular geometry. |
| Link the biological functions of compounds with its molecular geometry | [6]Group Activity<br>Groups will be assigned to work on different biological molecules and study how molecular geometry affects their properties and reactivity. |
| Appreciate the importance of knowing the shapes of molecules | Oral Recitation<br>Students will present their findings in the previous group study. Students will participate in the discussion orally. |

The results in the preparation stage guided the framework of the objectives of the module. Notably, the objectives of the module support the goals and objectives of the school's science program as well as the national and international goals in science education to: promote inquiry skills among students, promote appreciation of science using real-world applications, promote sustainable development and environmental protection, respond effectively to changing needs and conditions and enhance the range and quality of the individuals in the society. Interestingly, the module also answers to international trends in paradigm shift in teaching through the use of technology and the integrated approach to teaching science [10].

Table 2 presents the objectives of the module together with the teaching strategies that promote cooperative learning, inquiry, resourcefulness, and use of technology. Throughout the module, the students will learn to question and hypothesize; manipulate materials; observe, measure, and record data; and analyze and interpret results. With the practical applications and explorations of physical phenomena in everyday situations, students will appreciate learning science and the role of science in the society.

Items with numbers in the second column are teaching innovations featured in the module. The following statements outlines the features of each teaching innovation incorporated in the module. Due to lost parts of the ball-and-stick model in the laboratory, other material like balloon[1] are used in exploring VSEPR model. This balloon activity[2] can be also be used to model the formation of other geometries up to six electron domains. Recognizing the need for paradigm shift in education, android/apple Molecular Geometry Mirage[3] application is also utilized in the module. Due to the dwindling resources, students will learn how to be resourceful as they make their own set of molecular models using wood and clay[4]. They will also apply skills in measurement and craftsmanship and show ingenuity in doing a task. Additionally, students will also explore making human molecular models[4]. This is a very good activity to promote cooperation and coordination among members of a group. Moreover, a collection of carefully selected video presentations[5] will be used to showcase the importance and uniqueness of water. Most importantly, it will also show how scientist are even more amazed on how much power and beauty of water has not been known to mankind, yet. The discussion of molecular geometry will be extended to important molecules in our body like proteins, DNA, enzymes and its interactions with drugs. Moreover, students will investigate five different cases[6] wherein molecular geometry plays a crucial role to the molecules' function.

### *3.3. Formative Evaluation and Validation Stage*

Furthermore, based on Table 3 the computed value of Student Involvement Index (SII) was 2.03, which indicated a very acceptable value. This implied that the developed material was able to encourage more opportunities for student engagement. The SII value was obtained using the following computation.

Student Involvement Index (SII) = Total in II/Total in I

$$= 67/33 = 2.03$$

ICT instructional materials are prominently used in teaching science since they provide a means for students to clearly visualize the concepts and phenomena, especially those which are in microscopic scale [ 4]. With this, the abstractness of concepts is reduced. In effect, student can better understand the lesson and be engaged in learning science. The utilization of multimedia-based instructional material, particularly simulation, in teaching science are considered as a context-based approach since it can provide a learning environment that approximates the real-world making learning authentic [20]. In this light, it can be inferred that ICT learning materials can stimulate students' motivation and engagement by providing avenues to interact with the content and opportunities to have a control over the learning process [4,5,6].

**Table 3:** Student involvement index of the Module *Molecular Geometry: The Shape of Your Life*.

| Category | p1 | p2 | p3 | p4 | p 5 | p 6 | p7 | p 8 | p 9 | p10 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| I. Facts | 3 | 4 | 3 | 3 | | 5 | 4 | 2 | | 2 | 26 |
| Conclusions | 1 | | 2 | 2 | | | | | | | 5 |
| Definitions | 2 | | | | | | | | | | 2 |
| Questions answered immediately | | | | | | | | | | | |
| Total | | | | | | | | | 33 | | |
| II. Questions requiring students to analyze data | | 2 | | | | | | | | | 2 |
| Statements requiring students to formulate conclusion | 3 | 2 | 1 | 2 | | 2 | 5 | 7 | | 4 | 26 |
| Directions for students to perform and analyze and solve | | 2 | 1 | 1 | 6 | 3 | 1 | | 10 | 2 | 26 |
| Questions to arouse and not answered immediately | 1 | | 3 | 2 | 4 | | | 1 | | 2 | 13 |
| Total | | | | | | | | | 67 | | |

The module got an Outstanding rating from the teachers in which the marginal comments of evaluators included grammatical corrections, improvements on figures and labels. Further analysis using Fry readability index was implemented in the developed module. However, the first draft of the module showed that it was fitted to the reading age of Grade 11 (Grade 9+2) students. From this, it can be inferred that the readability is too high for the Grade 9 students, hence, careful review of the whole module is done to make sure that the readability index of the material fits intended users. Particularly, long words and complex sentences were broken into simpler sentences. To illustrate, the example of long compound sentence is as follows: *"Lewis structures illustrate how the outermost or valence electrons of around atoms and how they form bonds and lone pairs are also shown in the molecular compounds."* is revised to two simple, short sentences *"Lewis structures illustrate how the outermost electrons of atoms form bonds. Lone pairs are also shown."* The results of the readability index as well as the comments of the evaluators were considered in the revision of the module. Figure 2 illustrates the Fry graph for the readability index of the revised module.

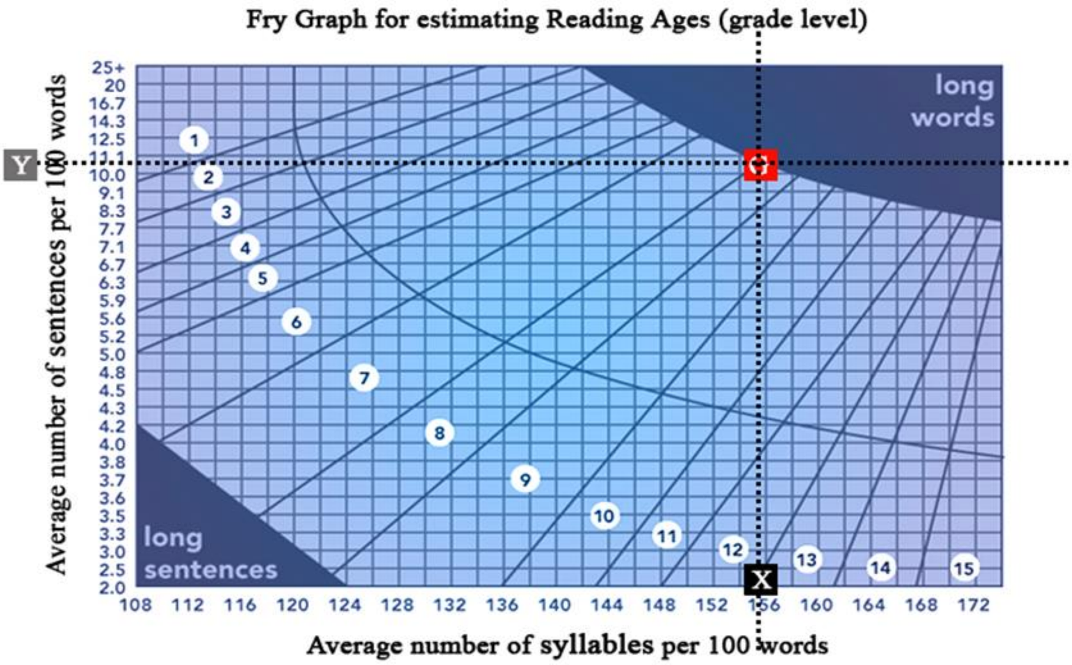


**Figure 2:** Fry's readability index of the module after revision Grade 9 (7+2).

Consequently, after the module revision, it was tried out to 60 Grade 9 students wherein they were given copies of the module and did all the activities in the module. Afterwards, the students answered a survey questionnaire which aims to evaluate the module in terms of clarity and appeal, determine the preparedness of the students for the lesson, and identify difficult words and unclear figures in the module. Aside from the Fry's readability index, another parameter measured in the evaluation of the module is the communication index of the curriculum material. This was implemented after the students were able to try out the developed module then they were asked to identify the unclear words. In the context of this research, the unclear words found in the 300-word sample are: equatorial position, molecular geometry (appears thrice), electron domain (appears six times), and reactivity (appears thrice). This makes the number of unclear words 13. The number of readers who found the words unclear are 1, 1, 2, and 1, respectively. The Communication Index (CI) of the module was computed as follows. The computed CI for the module is acceptable and commendable. The ideal value for CI is 0 and should not exceed 1.

$$CI = \frac{1(1)(1) + 1(3)(1) + 1(6)(2) + 1(3)(1)}{13\,(300)} = 0.004$$

Furthermore, findings in the researcher-made test revealed that 15.63% of the respondents gave Outstanding rating for the preparedness in the lesson. Majority, 71.88% gave Very Satisfactory rating, and a few, 12.50%, Satisfactory rating for their preparedness. These results could be attributed by the inclusion of advanced concepts in the module like polarity, reactivity, keratin, axial and equatorial that needs to have more emphasis in the discussion in the module. Such challenge could be addressed by providing brief definition or description of the advanced concepts in the module as well as using a more common and familiar terms of the words like contortion, ricochet, anomalous, discerning and salient. Nevertheless, 78.13% of the research sample expressed that were no boring part of the module. Meanwhile, in terms of clarity of the developed material, majority of the student evaluation showed Very Satisfactory overall rating from the research sample.

## 4. Conclusion

This study aims to develop a curriculum material which uses baseline data from the existing curriculum as well as feedbacks from students and teachers. It also considers institutional and national goals in education like inquiry approach, integration of technology, improvisation of materials, and seamless interdisciplinary approach to science. The study is anchored on the involvement of students and teachers in developing the curriculum material which make the material more relevant and useful. Moreover, this study uses technology that facilitates the delivery of content and simulation of models for molecular geometry chemistry topics. Further, the developed curriculum material is evaluated in terms of content, structure, and readability to the intended users. It has passed the parameters for both the internal and external evaluation of teachers and students. Majority of the students noted Very Satisfactory to Outstanding evaluation of the module. This could be attributed to the features of the module such as improvisation of materials, collaboration and group work, use of technology in science teaching, and investigating science cases related to chemistry and biology. The results of this study offered several implications in education. For instance, teachers and academicians must be guided that curriculum materials should be continuously evaluated and updated to keep up with the demands of the society and its users. The transformation theory of curriculum reform, that is, the current curriculum was reviewed and found to be needing restructuring, used in this study can be applied to other science subjects which need curriculum improvement or change. The baseline evaluation stage in curriculum development greatly aid in planning and drafting the restructured curriculum material. This research also underscores the importance of having well-conducted baseline evaluation. This phase in preparation stage of any research procedure should not be neglected since it helps the module obtained high teacher evaluation and minimal corrections. On the other hand, the internal and external formative evaluation refined and improved the curriculum material in terms of its appeal to students, communication index, student involvement index, readability and content. All the parameters in the internal formative stage must be within the acceptable level and the comments of the expert-teachers and students should be incorporated in the revised module. Truly, technology integration coupled with effective teaching strategies have promising contribution to improve the teaching and learning process by providing scaffolds and visuals to concretize ideas.

## 5. Recommendations

Based on the findings, the following studies are recommended. After at least one year of use, the developed module should undergo summative evaluation to measure its effect on education constructs like student academic performance, independent learning skills, and attitude towards science. The proven benefit and positive perception of students to technology may move teachers in other subject areas to incorporate technology in their curriculum materials. At the institutional level, it would be beneficial to partner with institutions which are centers on the development of technology applications for education.

## 6. Limitations of the Study

Several limitations to this study need to be acknowledged. There's still a need to increase the sample size of the present study and consider other perspectives from different types of school in order to make the results more generalizable and to gain additional insights. Nevertheless, the findings of the said study can be used as benchmark for future studies. Moreover, the present study only covered the implementation of the developed curriculum material to a single group of students. With this, it is recommended to utilize the developed curriculum material in a quasi-experimental design in order to compare the effectiveness of the curriculum material on other research parameters. Aside from measuring student involvement to assess the quality of the module, it would be noteworthy to measure cognitive and affective parameters as well as $21^{st}$ century skills.

## References


[1]. J. O. C. Bin & N. T. N. Ngoc. "The 4Cs Framework to Transform Higher Education Institution into an Innovation Producing Ecosystem," 5th National Conference in Science and Mathematics Education Towards Education 4.0, Bicol, Philippines.

[2]. Official Gazette. "Briefer on the Enhanced K to 12 Basic Education Program". Available: http://www.gov.ph/2010/11/02/briefer-on-the-enhanced-k12-basic-education-program/ [Aug. 16, 2019]

[3]. M. B. Nelson. "The Role of Technology in Curriculum Development and Delivery.", African Higher Education Review, 3, 83-97, Dec. 2010.

[4]. O. Ercan, K. Bilen, & E. Ural, E. "Earth, Sun and Moon: Computer assisted instruction in secondary school science-achievement and attitudes.", Issues in Educational Research, 26, vol. 2, 206-224, May 2016.

[5]. Lapinid, M.R.C. "Evaluation of the effectiveness of CAI modules in mathematics in intermediate grade school." Ph.D. Dissertation, De La Salle Univeristy, Philippines, 2014

[6]. O.F. Sözcü & I. İpek . "Considerations for IEl courseware design and the next generation of e-learning.", European Journal of Contemporary Education, vol. 6, 204-215, December 2013.

[7]. A. Efendioglu. "Courseware development model (CDM): The effects of CDM on primary school pre-service teachers' achievements and attitudes.", Computers and Education, 59, 687-700, Sept. 2012.

[8]. [8] Department of the Science and Technology-Science Education, University of the Philippines-National Institute of Science and Mathematics Education. Framework for Philippine Science Teacher Education. Manila: 2011.

[9]. S. A. Garba, Y. Byabazaire & A. H. Busthami. "Toward the use of 21st Century Teaching-Learning Approaches: The Trend of Development in Malaysian Schools within the Context of Asia Pacific." International Journal of Emerging Technologies, 10, vol. 4, September 2015.

[10]. Partnership for 21st century learning. "Framework for 21st century learning". Available: http://www.p21.org/our-work/p21-framework [Aug. 16, 2019]

[11]. National Education Association. "Preparing 21st Century Students for a Global Society: An Educator's

Guide to the 4Cs". Available: [June 30, 2019]

[12]. R. De Carvalho. (2014, month). "Thematic Curriculum Design, A Case Study: The Chemistry Subject Knowledge Enhancement Course." Investigations in University Teaching and Learning, vol. 9. Available: https://metranet.londonmet.ac.uk/fms/MRSite/psd/hr/capd/Investigations%20Vol%209/pdf/Inv%20009%20009%20De%20Carvalho.pdf [Aug. 10, 2015]

[13]. A. C. Ornstein, E. F. Pajak, & S. B. Ornstein. Contemporary Issues in Curriculum 5th Edition. New Jersey: Pearson Education Inc., 2011.

[14]. R. Ambag. "Teaching Science In The Philippines: Why (And How) We Can Do Better". Internet" https://www.flipscience.ph/news/features-news/features/teaching-science-philippines/, Aug. 3, 2018 [Nov. 24, 2020].

[15]. J.R., Orbe, A. A., Espinosa, & Datukan, J. T. "Teaching Chemistry in a Spiral Progression Approach: Lessons from Science Teachers in the Philippines", Australian Journal of Teacher Education, vol. 43, pp. 17-30, 2018.

[16]. International Council for Science. Report of the ICSU Ad-hoc Review Panel on Science Education, Paris: 2011.

[17]. D. L. Sunga & M. V. C. Hermosisima. "Exploring the Potentials and Essentials of Mobile-Aided Pedagogy in Teacher Education" The Normal Lights, Special Issue, 50-63, 2016.

[18]. D. Stamovlasis, N. Kypraios, & G. Papageorgiou. "A SEM model in assessing the effect of convergent, divergent and logical thinking on students' understanding of chemical phenomena" Science Education International, 26 vol. 3, 284-306, 2015.

[19]. C.T. Sunga & A. P. David. "Using Collaborative Formative Assessments in Enhancing Students' Understanding of Concepts in Grade 9 Electron Configuration" The Normal Lights, Special Issue, 82-97, 2016.

[20]. C. Kadash. "Context based simulation in nursing education: a student- centered experience towards pedagogical reform," 5th International Conference of Education, Research and Innovation. Madrid, Spain, 2012.