Forging 21\textsuperscript{st} century skills development through enhancement of K to 12 gas laws module: a step towards STEM Education

Manuel B. Barquilla\textsuperscript{1*} and Martiniano T. Cabili\textsuperscript{2}

\textsuperscript{1}Department of Science and Mathematics Education, College of Education, MSU-Iligan Institute of Technology, Tibanga, Iligan City, Philippines
\textsuperscript{2}Science Teacher, Lanao Del Norte Comprehensive High School, Tubod, Baroy Lanao Del Norte, Philippines
*Corresponding author email: manuel.barquilla@g.msuiit.edu.ph

Abstract. STEM Education though an old educational reform in US, Europe and other Asian countries is newly introduced to Philippine setting. Two notion confused educators whether the term is an approach or a track in the senior high school curriculum. The term STEM Education refers to the integration of Science, Technology, Engineering and Mathematics but the heart of it is simply to develop the students’ capability of 21st century skills needed of the time for a lifelong learning. This study aims to: (1) enhance students’ conceptual understanding and increase performance level through utilization of the enhanced module; to (2) develop students’ 21st Century skills, namely: collaboration, knowledge construction, self-regulation, real-world problem solving skills, use of ICT for learning and skilled communication; and to (3) proposed STEM education Lesson plan on topic Gas Laws. The researcher employed experts (in content and pedagogy) to evaluate and rate specific topic on Gas laws, from the original learning module of the Department of Education (DepEd) K to 12 curriculum materials, using the 21st Century Learning Design Rubrics (21CLD). Results yielded low ratings thereby providing basis for module enhancement. Enhancement and revision of the module were done based on the experts’ formative evaluation. After science and Technology High School, school year 2017-2018, who were paired according to pretest results and were regrouped into experimental and control group for quasi-experimental design interpretation. A suggested STEM education lesson plan was generated to further integrate their concepts in gas laws and its application to technology, engineering and mathematics. Findings indicated that students in the experimental group not only developed and improved their 21st century skills with the aid of the enhanced module but also significantly improved their conceptual understanding and performance level as compared to the control group. Generally, this study provides enough evidence that the enhanced module brought significant impact to students’ academic performance. Study recommends using the enhanced module in public schools to cater the needs of the 21st century learners. Furthermore, it is suggested that STEM lesson plan as an approach be prepared after the specific lesson on Gas laws will be introduced for students to fully integrate Science, Technology, Engineering and Mathematics in the issues and its applications about the topic.

Keywords: STEM education, gas law, 21\textsuperscript{st} century skills
1. Introduction
The Department of Education in the Philippines is looking for the development and effectiveness of the K to 12 curriculum materials that will cater all types of learners. In fact, there are several issues and concerns arise upon the implementation of this new curriculum. One of those is the innovation in teaching especially in science classes using the spiral progression approach [10], [2].

Learning activities and varied techniques must be applied to the students to keep their interest in the teaching and learning process [3]. Thus, providing them with appropriate teaching methods or strategies that are necessary to attain lifelong learning and become competent enough to face any given task in this dynamic and real world [13], [14], [15], [16]. According to the experimental theory (Learning by Doing Theory) of John Dewey as cited by Guarin [6], people learn best when they are personally involved in the learning process. Thus, the teachers are expected to encourage the students to engage themselves in the teaching-learning process.

Teaching Chemistry is indeed a big challenge for science teachers. Learners generally perceived Chemistry as difficult and boring subject because of their learning environment, some teacher factors and due to the nature of the subject. Therefore, several researchers are adopting innovative strategies to enhance the teaching-learning process [1]. In view of this, the researcher is conducting a study with the aid of innovative strategy and utilizing enhanced K to 12 Grade 10 gas laws module. The aim is to help the students develop 21st century skills; collaboration, knowledge construction, self-regulation, real-world problem solving and innovation, the use of ICT for learning and skilled communication utilizing the 21st century learning design rubrics [7], [8], [9].

At present time, the 21st century skills are very significant in meeting the demands of the present curriculum [4]. In addition to this, the Department of Education aims better and brighter goals to produce productive and competitive learners most especially in teaching science subjects. The DepEd also provide the science activity manuals to grade 10 students all throughout the country. However, science teachers are just using the textbook provided by the government which is not utilizing the 21st century skills. In this study, the researcher will be concentrating on grade 10 chemistry classes in gas laws module. The researcher will use this as a tool to have a better method for lifelong learning.

Furthermore, STEM Education as an approach is needed to fully integrate students’ innovative creation in the application of science, technology, engineering and mathematics in a solve societal issues. Thus, developing students’ ingenuity and creativeness should be provided for lifelong learning.

The Department of Education is working its best for the full implementation of the K to 12 Philippine Education system. Modular textbooks were given to the different schools intended for the learners and teachers in achieving the demands set by the educational system [12]. The major objective of the research is to produce a curriculum material that will help enhance the conceptual understanding of the students with the use of the enhanced module for gas laws which utilized the 21st century learning design rubrics [9]. The researcher believes that the use of the enhanced module for gases will aid students in understanding science concepts and develop their 21st century skills. This study will then serve as a stimulus for further enhancement and innovation in teaching such as utilizing STEM education approach in the teaching the subject.

1.1 Objectives of the Study
This study aims to:
(1) enhance students’ conceptual understanding and increase performance level through utilization of the enhanced module;
(2) develop students’ 21st Century skills, namely: collaboration, knowledge construction, self-regulation, real-world problem solving skills, use of ICT for learning and skilled communication; and
(3) propose STEM education Lesson plan on topic Gas Laws.

1.2 Scope and Limitation
This study is limited to the enhancement of seven (7) activities of gas laws module only of grade 10 of the K to 12 curricula utilizing the 21st century learning design rubrics. The first stage of enhancement was in accordance to the rubrics of the 21st Century Learning Design (21 CLD) [11] and then from the comments and suggestions of the In-Service Chemistry Teachers of the public schools who evaluated
the enhanced activities. The enhancement, validation, and utilization of enhanced module were subjected to scrutinization and revisions with the help of the experts. Two experts in the content, two experts in pedagogy, two end user teachers were asked to validate the enhanced module utilizing the 21st century learning design. The implementation was done among Grade 10 students of selected public school who are officially enrolled for this school year 2017-2018. Two groups were identified as experimental and control. The experimental group made use of the enhanced K to 12 modules on Gas Laws while the control group utilized the DepEd Original Module on Gas Laws.

2. Methodology

2.1 Research Design

The study used qualitative and quantitative research design to determine the impact of enhanced activities in learning chemistry lessons among grade 10 students. The quantitative data were taken from the ratings that were given by the experts on the enhanced module and the results of pretest and posttest. The qualitative data were taken from the comments and suggestions of the experts on the enhanced gas laws. The researcher utilized the 21CLD Rubrics as the basis for evaluation.

The study made use of two groups-control and experimental- where students were grouped accordingly and were subjected to nonrandom pretest and posttest experimental design. The control group used the original DepEd gas laws module while the experimental group used the enhanced gas laws module incorporating 21st century skills. The grouping was based on their pretest scores. Pairing of the respondents using the said score were assigned in experimental and in the control group. Groupings were evaluated using homogeneity test based on standard deviation and mean scores. It was followed by the implementation of the original and enhanced module.

2.2 Research Locale

The study was conducted in Lanao del Norte Provincial Science and Technology High School located in Malingao, Tubod, Lanao del Norte. It is considered as one of the performing schools in the Division of Lanao del Norte because of its increasing NAT results. At present, the school is composed of 974 students with 28 active teachers. The school was founded last 2003.

2.3 Subjects of the Study

The subjects of the study were the Grade 10 students of two selected sections from LNPSTHS. The study utilized the ratings of the content experts who are both chemistry majors from MSU-IIT, one is a PhD degree holder and another one is a Master’s Degree holder; and pedagogy experts who are both degree holders in Master in Science Education and are both working the College of Education; and, the end users who are the two in-service chemistry teachers handling chemistry subjects from the start of the K to 12 program until at present and have taught the subject for more than 6 years in the Department of Education. Lastly, this study made use of the students who were both respondents of the study and are officially enrolled for the school year 2017-2018.

2.4 Data Gathering Procedure

This study follows the procedures as following. The first step in the data gathering procedure was the evaluation of the seven (7) original K to 12 Grade 10 Chemistry Module on Gas Laws utilizing the 21st Century Learning Design rubrics as reference by the experts in content, pedagogy, and end users. Using the 21st Century Learning Design rubrics the evaluated original activities were enhanced by the researcher with help and guidance of the team expert. These were then subjected to series of revisions and when finalized it was evaluated again by the experts and the in-service teachers. After approval of the final enhanced activities, the researcher implemented the enhanced activities to grade 10 students. After a series of revisions and evaluation of the enhanced activities the pretest was administered to the respondents to check their prior knowledge about chemistry lessons.

Before the implementation of the enhanced activities, the researcher asked first the permission from the school division superintendent office and luckily got the approval from the superintendent. After this, the researcher presented the approved letter from the division office to the secondary school
principal of Lanao del Norte in the Philippines Provincial Science and Technology High School and asked permission for the conduct of the enhanced activities. After the principal’s approval, the researcher was then endorsed to one of the class advisers of the respondents for the implementation since the other group of respondents are under the advisory of the researcher. By the time that the permission was given, the researcher administered the pretest to check the prior knowledge of the students before the implementation of the study. The respondents for the control and experimental group were determined and divided equally using the pretest scores. After identifying the two groups of respondents, the researcher then implemented the original K to 12 Gas Laws module to the control group and the enhanced K to 12 Gas Laws module to the experimental group. After the implementation process, the posttest was administered to the respondents to evaluate the effectiveness of the original and enhanced modules in terms of the conceptual understanding of the learners. And after this long process, the data were collected and analyzed.

2.5 Research Instruments Used

The study utilized the following instruments:

2.5.1 Achievement Test - The researcher used a teacher made test in implementing the achievement tests to the respondents. The tests measured the conceptual understanding of the respondents on gas laws. The teacher made test is composed of 25-item multiple choice questions on gas laws. This was evaluated and validated with the help of the content experts in chemistry. The test was answered by the control and experimental group and this was done individually where confidentiality of the results was observed properly.

2.5.2 The 21st Century Learning Design Rubrics This study utilized the 21st Century Learning Design Rubrics as the main tool in the evaluation and enhancement of gas laws chemistry module. The purpose of the 21st Century Learning Design rubrics is to help educators identify and understand the opportunities that learning activities give learners to build 21st century skills. These rubrics were developed and tested internationally for innovative teaching and learning research project. These described six rubrics of 21st century learning, each represent important skills for learners to develop collaboration, knowledge construction, self-regulation, real-world problem-solving and innovation, the use of ICT for learning and skilled communication [12]

2.5.3 ICT Materials - In conducting the study, the researcher used ICT materials like computer, projector, LCD TV screens, cellular phone, digital sound speakers, and digital presenter. These materials helped in the success of this study because the respondents are technologically equipped due to the advances of technology [5].

2.5.4 Original and Enhanced Modules-The researcher had used the original DepEd K to 12 grade 10 gas laws module in the control group. On the other hand, the enhanced module utilizing 21st century skills were used for the experimental group.

2.5.5 Lesson Plans - The researcher also used 7 E’s Model in lesson planning in the implementation for both the control and experimental groups. A revised STEM Education by Sushapan and Yuenyong [13] was then proposed for the next implementation of this study.

2.6 Statistics and Data Analysis

2.6.1 Statistical Tool used. This study used three statistical tools for data analysis, namely: The Mean that measures the central tendency (Mean, Median, and Mode), score dispersion (SD), Paired t-test and the Wilcoxon Signed Ranks Non-Parametric Test. The use of open software for statistics was used in this study.

2.6.2 Qualitative Data Analysis

2.6.3 Coding of Data

To interpret the impact of the enhanced K to 12 Gas Laws module to the 21st century skills and performance of the respondents, a coding of data was made to hide and protect the identity of the content and pedagogy experts, teacher and student respondents
3. Results and discussion

3.1 Rating of Experts and End Users of the Original Activities Utilizing the 21st Century Learning Design Rubrics.

### Table 1. Mean Ratings of the Original Activities in the DepEd Module

| Activities                          | 21st Century Skills Employed | Original Activities | CE1 | CE2 | PE1 | PE2 | ISCT1 | ISCT2 | Mean | Section mean |
|-------------------------------------|------------------------------|---------------------|-----|-----|-----|-----|-------|-------|------|--------------|
| 1. Properties of Gases              | Collaboration                |                     | 1   | 2   | 1   | 1   | 2     | 1     | 1.5  | 1.40         |
|                                     | Skilled Communication        |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  |              |
| 2. Boyle’s Law                     | Collaboration                |                     | 1   | 2   | 1   | 1   | 2     | 1     | 1.5  | 1.54         |
|                                     | Skilled Communication        |                     | 1   | 3   | 1   | 1   | 2     | 1     | 1.5  |              |
|                                     | Real-World problem-Solving Skills and Innovation | | 3   | 2   | 1   | 1   | 1     | 2     | 1.7  |              |
|                                     | Self-Regulation              |                     | 3   | 3   | 1   | 1   | 1     | 1     | 1.7  |              |
|                                     | Use of ICT                   |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  |              |
| 3. Charles’s Law                   | Collaboration                |                     | 1   | 2   | 1   | 1   | 1     | 1     | 1.2  | 1.48         |
|                                     | Skilled Communication        |                     | 1   | 3   | 1   | 1   | 2     | 1     | 1.5  |              |
|                                     | Real-World problem-Solving Skills and Innovation | | 3   | 2   | 1   | 1   | 1     | 2     | 1.7  |              |
|                                     | Self-Regulation              |                     | 3   | 3   | 1   | 1   | 1     | 2     | 1.7  |              |
|                                     | Use of ICT                   |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  |              |
| 4. Gay Lussac’s Law                | Collaboration                |                     | 1   | 2   | 1   | 1   | 2     | 1     | 1.3  | 1.42         |
|                                     | Skilled Communication        |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  |              |
|                                     | Real-World problem-Solving Skills and Innovation | | 2   | 2   | 1   | 1   | 1     | 2     | 1.5  |              |
|                                     | Self-Regulation              |                     | 3   | 3   | 1   | 1   | 1     | 1     | 1.7  |              |
|                                     | Use of ICT                   |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  |              |
| 5. Activity Combined Gas Laws       | Knowledge Construction       |                     | 3   | 4   | 1   | 1   | 3     | 1     | 2.2  | 2.2          |
| 6. Activity Squashing the Bottle    | Skilled Communication        |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  | 1.3          |
|                                     | Use of ICT                   |                     | 1   | 3   | 1   | 1   | 1     | 1     | 1.3  | 1.3          |
| 7. Activity Gaseous Outlook         | Knowledge Construction       |                     | 1   | 4   | 1   | 1   | 1     | 1     | 1.5  | 1.5          |
|                                     | Real-World problem-Solving Skills and Innovation | | 1   | 3   | 1   | 1   | 1     | 2     | 1.5  | 1.5          |
| Grand Mean                          |                              |                     |     |     |     |     |       |       | 1.55|              |

Legend for Collaboration, Use of ICT and Skilled Communication, and Knowledge Construction.

1 = lowest rating and does not develop collaboration, Use of ICT and Knowledge construction Skills.
3 = highest rating develops collaboration, Use of ICT and Knowledge construction Skills. Passing at least 3.0.

Legend for Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills.

1 = lowest rating and does not develop Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills.
4 = highest rating and develop Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills. Passing at least 2.0
Figure 1. Mean Rating of the Content, Pedagogy Experts and End-Users of the Seven Activities of DepEd Module in Gas Laws.

As shown in table 1, the ratings on content, pedagogy and end users of the module for grade 10 has a mean rating below passing in six out of the seven (7) activities with the grand mean of 1.55. As indicated not all activities have the six skills. For example, in activities 1, 6 and 7 only two skills were developed. Activity number 5 has only one skill being developed but was rated with a section mean of 2.2 or labeled as Passed. Only three (3) of the seven activities showed five 21st century skills that have been developed. As such, the results suggest that the module on gas laws with seven activities must be thoroughly be enhanced as it yielded a failing grand mean rating which indicates that the six identified skills were not developed. This context is further illustrated in figure 2.

Figure 2 indicated that the module needs to be revised and enhanced in such a way that it can improve learning and provide conceptual understanding to students and will help develop their 21st century skills. This evaluation will serve as a baseline data and springboard to where enhancement could be done on the module of Gas laws.

3.2 Activities Needing Enhancement Based on the 21st Century Learning Design Rubrics

Using the baseline data in objective 1, it was indicated that all activities be enhanced in the DepEd module of Gas laws. The researcher however decided to limit on increasing enhancement of students’ engagement but not expanding on activities to enrich 21st century skills. The rationale of the researcher is that after the student finished the module all the six (6) 21st century skills is hoped to be developed. Thus, in reiterating Figure 4, generally, all activities need to be enhanced in attunement to the 21st century skills. As indicated all the learning activities on the original module have low mean ratings which means that activities 1, 2, 3, 4, 6, and 7 need enhancement to satisfy the requirements of the 21st century learning design rubrics. The data show that activities 1, 2, 3, 4, 6 and 7 have the mean values below 2.0 which means all these activities can be subjected to enhancement using the 21st century learning design for 21st century learners. Although, activity 5 has a value of 2.2 yet it is still low to acquire the 21st century skills. In 21 CLD rubrics for collaboration, the highest possible rating is 5, which means that the students are sharing responsibility fairly; they make substantive decisions together, but their work is interdependent. For Skilled communication, the highest attainable rating is 4, which means that the students are required to produce extended communication or multi-modal communication; required to provide supporting evidence; and required to design their communication
for an audience. For Knowledge construction, the highest attainable rating is 5, which means the students’ main effort is knowledge construction and the work does not demonstrate conceptual understanding, and the students did apply their knowledge, or the work is interdisciplinary. For the use of ICT, the highest possible rating is 5, which means that the students demonstrate the use of knowledge construction supported by ICT and that ICT was required for constructing the knowledge and designed a product that demonstrate attention to authentic users in its design this is congruent to the study of Farasi [5]. Lastly, for the real-world problem solving and innovation, the highest attainable rating is 4, which means that the students main effort is problem solving and the solution did address a real-world problem and the solution was successful and the students did innovate and did a solution of real-world problems, as shown in Figure 3.

Thus, all activities on Gas laws module need enhancement and in connection to this, DepEd chemistry learning modules should utilize 21CLD rubrics to develop the 21st century skills of the learners.

![Mean Ratings of Original Activities](image)

**Figure 2.** Identified Activities on Gas Laws Module that Need Enhancement

### 3.3 Enhancement of the Activities of Grade 10 K to 12 Gas Laws Module.

The researcher has enhanced the module on Gas Laws of the grade 10 K to 12 modules by following the 21CLD Rubrics in collaboration, knowledge construction, self-regulation, real world problem-solving and innovation, the use of ICT for learning and skilled communication. The enhancement was made to meet the standards of the 21st century skills of the learners. The activities have undergone series of revisions with the help of the adviser and panel members. Then the evaluation of the experts was conducted in acquiring the ratings for the enhanced activities that is shown in Table 2.
Table 2. Experts’ Evaluation of the Enhanced Activities

| Activities                        | 21st Century Skills Employed                   | Original Activities | CE1 | CE2 | PE1 | PE2 | ISCT1 | ISCT2 | Mean | Section mean |
|-----------------------------------|------------------------------------------------|---------------------|-----|-----|-----|-----|-------|-------|------|-------------|
| 1. Activity Properties of Gases   | Collaboration                                   | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  | 4.40        |
|                                   | Skilled Communication                           | 4                   | 4   | 3   | 4   | 4   | 4     | 4     | 4.0  |             |
| 2. Boyle’s Law                   | Collaboration                                   | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  | 4.22        |
|                                   | Skilled Communication                           | 4                   | 4   | 4   | 4   | 4   | 4     | 4     | 4.0  |             |
|                                   | Real-World problem-Solving Skills               | 4                   | 3   | 3   | 3   | 4   | 3     | 4     | 3.5  |             |
|                                   | Self-Regulation                                | 4                   | 4   | 3   | 4   | 4   | 3     | 4     | 3.8  |             |
|                                   | Use of ICT                                     | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  |             |
| 3. Charles’s Law                 | Collaboration                                   | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  | 4.22        |
|                                   | Skilled Communication                           | 4                   | 4   | 4   | 4   | 4   | 4     | 4     | 4.0  |             |
|                                   | Real-World problem-Solving Skills               | 4                   | 3   | 3   | 3   | 4   | 3     | 4     | 3.5  |             |
|                                   | Self-Regulation                                | 4                   | 4   | 3   | 4   | 4   | 3     | 4     | 3.8  |             |
|                                   | Use of ICT                                     | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  |             |
| 4. Gay Lussac’s Law              | Collaboration                                   | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  | 4.22        |
|                                   | Skilled Communication                           | 4                   | 4   | 4   | 4   | 4   | 4     | 4     | 4.0  |             |
|                                   | Real-World problem-Solving Skills               | 4                   | 3   | 3   | 3   | 4   | 3     | 4     | 3.5  |             |
|                                   | Self-Regulation                                | 4                   | 4   | 3   | 4   | 4   | 3     | 4     | 3.8  |             |
|                                   | Use of ICT                                     | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  |             |
| 5. Activity Combined Gas Laws    | Knowledge Construction                          | 4                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  | 4.80        |
| 6. Activity Squashing the Bottle | Skilled Communication                           | 4                   | 4   | 4   | 3   | 4   | 4     | 4     | 3.8  | 4.30        |
|                                   | Use of ICT                                     | 5                   | 5   | 5   | 5   | 5   | 5     | 5     | 5.0  |             |
| 7. Activity Gaseous Outlook      | Knowledge Construction                          | 4                   | 5   | 5   | 4   | 5   | 5     | 5     | 4.7  | 4.20        |
|                                   | Real-World problem-Solving Skills               | 4                   | 4   | 4   | 3   | 3   | 4     | 4     | 3.7  |             |

Legend for Collaboration, Use of ICT and Skilled Communication, and Knowledge Construction.
1 = lowest rating and does not develop collaboration, Use of ICT and Knowledge construction Skills.
5 = highest rating develops collaboration, Use of ICT and Knowledge construction Skills.
Passing at least 3.0.

Legend for Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills.
1 = lowest rating and does not develop Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills.
4 = highest rating and develop Skilled Communication, Real-World Problem-Solving Skills and Innovation and Self-Regulation Skills.
Passing at least 2.0

Table 2 shows the ratings of the experts and in-service chemistry teachers in the enhanced K to 12 gas laws module in utilizing the 21st century learning design rubrics. All mean values yielded high ratings that satisfy the standards of collaboration, knowledge construction, self-regulation, real world problem-solving and innovation, the use of ICT for learning and skilled communication rubrics. This can be further gleaned in Figure 5.
Figure 3. Comparison of the Original and Enhanced Module Ratings in the 7 Activities

As shown in figure 3, enhancing the module resulted in an increase of content, pedagogy, and end-user ratings. In comparison with figure 5 data clearly indicate that the enhanced rating has a grand mean of 4.38, enabling students to acquire the 21st-century skills to the highest degree.

Thus, enhancing the DepEd module will help students attain the 21st-century skills required and develop their conceptual understanding.

3.4 Content Validity, Readability and Student Involvement Index of the Module

To determine content validity, readability, and student involvement index, experts on content were given the copy to validate the accuracy, possible misconceptions, and corrections of the concepts in the module. Readability was analyzed using the Flesch-Kincaid Readability Ease and computation for student involvement index was done.

3.4.1 Content Validity

The content of the module was checked and validated by the two content experts in chemistry.

The enhanced activities were scrutinized in terms of content accuracy and misconceptions. After identifying the wrong concepts, the researcher had revised the module based on the corrections and inputs of the content experts. For example, a misconception was presented in the module that stated “The basketball is filled with air, so it bounces when you are dribbling it. The same is true with the other kinds of balls.” This was corrected by the expert that not all kinds of balls that are filled with air will bounce because there are also balls that are not filled with air that can also bounce. Another example correction from another expert is that there was a part in the module that presented a wrong method of writing the formula, so it was corrected and changed by the researcher to avoid misconceptions in formula writing. After a series of revisions, the module was then subjected to evaluation utilizing the 21 CLD Rubrics.

Thus, in making the enhanced module, it is necessary to ensure the correct concepts that would be presented to learners and educators.
3.4.2 Readability

Table 3. Flesch-Kincaid Readability Level

| Readability Test | Activity 1 | Activity 2 | Activity 3 | Activity 4 | Activity 5 |
|------------------|------------|------------|------------|------------|------------|
| Flesch-Kincaid Reading Ease | 64.7 | 60 | 67 | 59.7 | 58.6 |
| Flesch-Kincaid Grade Level | 7 | 9 | 7 | 8 | 9 |

Table shows the readability level of the enhanced K to 12 Gas Laws Module. The Flesch-Kincaid Reading Ease 60 and above means that the reading level is under standard/average level. This means that the enhanced module is easy to read. For Flesch-Kincaid Grade Level, as shown in the table, the enhanced gas laws K to 12 modules could be read by grade 7, 8 and 9 students easily. This means that the grade 10 students can also read the enhanced module easily. Thus, the reading ease of the module is typically intended even for grade 7 to 9 and much easier to understand by a grade 10 student.

3.4.3 Student Involvement Index

The total student involvement in category I is 120 while category II is 105. The student involvement index is 0.88, which means that a student will be involved in the enhanced activity 88% of the time. This suggests that the enhanced module provide avenue to student in participating more in the modular activities.

3.5. Evaluation, Comments and Suggestions from Experts

3.5.1 Evaluation of Experts on the Original and Enhanced Module

Table 4 shows the mean ratings of the experts in the original and enhanced activities of the gas laws K to 12 modules. Results show that the grand mean rating of the original activities is low (1.55) and does not follow the standards of 21CLD rubrics for 21st century skills. On the other hand, the enhanced module got high mean rating of 4.38 and met the standards of the 21CLD rubrics.

3.5.2 Comments and Suggestions of Experts and End Users

The comments and suggestions of experts and end users are categorized by themes. There were seven (7) themes identified and all of these are positive towards the utilization of the module.

1. The Module can develop higher order thinking skills (HOTS) and provide proper task dissemination according to end user (teacher).

According to an end user, the enhanced module can develop higher order thinking skills (HOTS) as she states that:

- “The enhanced module basically caters the needs of our 21st century learners. It’s good to have these kinds of activities to be implemented to our 21st century learners because it develops their higher order thinking skills, abilities and learning dispositions. The content is not just knowledge-based, but it is associated with deeper learning which is based on mastering skills as analytic reasoning, problem solving and teamwork.” (ISCT1)

Another comment from an end-user that module has a proper dissemination. She puts:

- “Instructions were well given and proper task dissemination among members of the group.” (ISCT2)
Table 4 Mean Rating of the Original and Enhanced Activities.

| Activities                      | 21st Century Skills Employed | Original Activities Mean Rating | Enhanced Activities Mean Rating |
|---------------------------------|------------------------------|---------------------------------|---------------------------------|
| Activity 1. Properties of Gases | Collaboration                | 1.5                             | 5.0                             |
|                                 | Skilled Communication        | 1.3                             | 3.8                             |
| Activity 2. Boyle’s Law         | Collaboration                | 1.5                             | 5.0                             |
|                                 | Skilled Communication        | 1.5                             | 4.0                             |
|                                 | Real-World problem-Solving   | 1.7                             | 3.5                             |
|                                 | Skills                       | 1.7                             | 3.8                             |
|                                 | Use of ICT                   | 1.3                             | 4.8                             |
| Activity 3. Charles’ Law        | Collaboration                | 1.2                             | 5.0                             |
|                                 | Skilled Communication        | 1.5                             | 4.0                             |
|                                 | Real-World problem-Solving   | 1.7                             | 3.5                             |
|                                 | Skills                       | 1.7                             | 3.8                             |
|                                 | Use of ICT                   | 1.3                             | 4.8                             |
| Activity 4. Gay Laussac’s Law   | Collaboration                | 1.3                             | 5.0                             |
|                                 | Skilled Communication        | 1.3                             | 4.0                             |
|                                 | Real-World problem-Solving   | 1.3                             | 3.5                             |
|                                 | Skills                       | 1.7                             | 3.8                             |
|                                 | Use of ICT                   | 1.3                             | 4.8                             |
| Activity 5. Combined Gas Laws   | Knowledge Construction       | 2.2                             | 4.8                             |
| Activity 6. Squashing the Bottle| Skilled Communication        | 1.3                             | 3.8                             |
|                                 | Use of ICT                   | 1.3                             | 4.8                             |
| Activity 7. A Gaseous Outlook   | Knowledge Construction       | 1.5                             | 4.7                             |
|                                 | Real-World problem-Solving   | 1.5                             | 3.7                             |
| Grand Mean:                     |                              | 1.55                            | 4.38                            |

2. The module is easy to understand and interesting and exciting according to end users (Students). They said that:

- “I can easily understand the procedure in the activities because all are written in clear way.” (S1)

Also, other students commented that,

- “The activities are all interesting and exciting because it will expose us to different styles in teaching that will help us develop our 21st century skills.” (S2)

3. The module will improve performance of the students and develop the 21st century skills, as chemistry experts said:

- “The enhanced module makes the activities: collaborative, interactive, with sense of responsibility in acquiring data, involves critical thinking, has multi-tasking interpreting and processing data.” (CE1)
- “It is better than the original because not only is collaboration incorporated in the activities but also other useful and significant 21st century skills.” And
"I am confident that the learning of the students in this subject with enhancement activities would greatly increase." (CE2)

4. The enhanced module is realistic, and the procedures are clear as stated by the pedagogy experts.

  - "Objectives are realistic and attainable." (PE 1)
  - "Procedures are very clear. Students can understand it well." (PE2)

  However, they provided also some suggestions in the calculations and predictions.

  1. Calculation and Prediction.
     - "In calculation portion, it is good to know the changes that will happen to each variable." (ISCT1)
     - "Add prediction in the calculation. After giving the given, it is good to predict after observing all the given. Simple prediction whether there is increase or decrease in the variable in relation to another variable." (ISCT 2)

  2. Employment of Several Skills in the Activity.
     - "Not to employ too many skills in one activity because often times it would be too tasky for the students even if it will be done in a group." (CE1)
     - "Target skills can be set as a chapter or unit not per activity."

According to the comments and suggestions of the experts, in-service teachers and students written above, the enhanced module is truly beneficial for the 21st century learners in developing their 21st century skills that would make them competitive. But one of the suggestions is that there should be a limit in the skills to be employed in each activity.

3.6 Quality of output of Students in Original and Enhanced Activities.

  In assessing the quality of output produced by the students using the original and enhanced activities, the two groups with both heterogeneous classes revealed result shown in table 5.

  The original module was implemented with the original activities and the mode of delivery was retained. Thus, the mean score was taken from the individual performance of the students on the activity. On the other hand, the experimental group was implemented with the enhanced activities where group work was implemented. Although the enhanced module has many activities compared to the original activities, the grading was based on the percentages of the scores. For example, in activity 1 for the original activity the total score is 55 and the mean score of the learners is 48.85 which is equal to 87.17%. On the other hand, in the enhanced module the total score is 57 and the mean score of the students is 50.10 which is equal to 89.50%.
Table 5. Mean Percentage Comparison of Using Original and Enhanced Modules

| Original Activities | Mean Scores (Original Module) | Enhanced Activities | Mean Scores (Enhanced Module) |
|---------------------|--------------------------------|---------------------|-----------------------------|
| Getting to          | 87.17                          | 1. Properties of Gases | 89.50                      |
| 2. Boyle’s Law      | 80.30                          | 2. Simple Gas Laws in Action | 89.46                      |
| 3. Charles’ Law     | 72.56                          | √ Boyle’s Law        | 89.46                      |
| 4. Gay-Lussac’s Law | 70.06                          | √ Charles’ Law        | 89.46                      |
| 5. Combined Gas Laws| 65.32                          | √ Gay-Lussac’s Law   | 89.46                      |
| 6. Squashing the Bottle | 61.00                       | 3. Combined Gas Laws | 88.11                      |
| 7. Gaseous Outlook  | 68.79                          | 4. Ideal Gas Law     | 81.26                      |
| Grand Mean          | 72.17                          | Grand Mean           | 87.03                      |
| Standard Deviation  | 8.93                           | Standard Deviation   | 3.75                       |

As shown in table 5, the grand mean of the students who were subjected to enhanced activities is 87.03% compared to the grand mean of the students who were subjected to the original activities that is 72.17%. This means that the students who were subjected to the enhanced activities have a bigger percentage of passing than the students who were using the original activities. The data also show that the standard deviation of the enhanced module is lower compared to the original. This means that more students are directed to such learning in the experimental group than the control. Thus, these are evidences to show that the enhanced module can provide better output as compared with the original module. Meaning, it will promote conceptual understanding among students.

3.7 Comparison of the Pretest-Pretest, Pretest-Posttest and Post-Post Test Results

Table 6. Comparison of the Pretest Scores between the Control and Experimental Groups

|                   | Control Pretest | Experimental Pretest |
|-------------------|-----------------|----------------------|
| Mean              | 7.49            | 7.39                 |
| Standard Deviation| 2.34            | 2.16                 |
| Mean Difference   | 0.10            |                      |
| SD Difference     | 0.17            |                      |
| t-value           | 0.24*           |                      |
| p-value           | 0.807           |                      |

* significant at 0.05 level
Table 6 shows that there is no significant difference between the pretest-pretest results in both control (7.49) and experimental (7.39) groups since the p-value is 0.807 and is greater than 0.05 level of significance. This means that students in both control and experimental groups had the same average performance and are almost equally the same as observed also in their mean scores.

Table 7. Pretest and Post Test Results Using Paired t-Test.

|                  | Control     | Experimental |                  |                  |
|------------------|-------------|--------------|------------------|------------------|
|                  | Pretest     | Posttest     | Pretest          | Posttest         |
| Mean             | 7.49        | 14.76        | 7.39             | 19.22            |
| Standard Deviation | 2.34        | 3.75         | 2.17             | 3.48             |
| Mean Difference  | -7.27       | -11.83       |                  |                  |
| SD Difference    | 3.72        | 3.60         |                  |                  |
| t-value          | -15.00*     | -25.27*      |                  |                  |
| p-value          | 0.000*      | 0.000*       |                  |                  |
| * significant at 0.05 level

Table 7 shows that there is a significant difference between the pretest and post test results in both control and experimental groups since the p-values are less than 0.05 level of significance. This means that the students in both control and experimental groups perform better in the posttest than in the pretest as observed also in their mean scores but with enhanced module, students scored much higher in the posttest as compared to those in the control group. Thus, the first null hypothesis is rejected.

Performance of students is also assessed through determining students’ conceptual understanding by the achievement test. Figure 6 further shows the performance of students conjoining the pretest and posttest.

![Figure 4](image-url) Comparison of Achievement Test Scores in the Pre and Posttests of Students Using the Enhanced Module.
As presented in the figure 4, the scores in posttest were doubled after the treatment is given. Thus, it is an indicator that the treatment improves the students’ conceptual understanding.

Table 7 further stipulates the significance difference in their scores. It is indicated that the p-value in both control and experimental are lower than 0.05 which give the basis to reject the null hypothesis that there is no significant difference between the pretest and posttest. Therefore, both treatments can foster change of ideas in the concept of Gas Laws. However, it can be noted that mean performance of enhanced activities (experimental) is higher as compared to the original (control). Also, the variability of scores is lower in experimental than control. Meaning, more students in the experimental performed better using the enhanced activities as compared to the students in the control group.

**Table 8** Comparison of the Posttest Scores Between the Control and Experimental Groups.

|                     | Control Posttest | Experimental Posttest |
|---------------------|------------------|-----------------------|
| Mean                | 14.76            | 19.22                 |
| Standard Deviation  | 3.75             | 3.48                  |
| Mean Difference     | -4.46            |                       |
| SD Difference       | 0.27             |                       |
| t-value             | -6.69*           |                       |
| p-value             | 0.000*           |                       |

* significant at 0.05 level

Table 8 shows that there is significant difference in the posttest scores between the control (14.76) and experimental (19.22) groups since the p-value (0.000) is less than 0.05 level of significance. This means that the students in the experimental group using the enhanced gas laws module using 21CLD Rubrics performed better than the students in the control group using the original activities as observed also in their mean scores. This implies that the impact of the enhanced module to the students’ performance is greater than the original module.

Based on the post-post test results, and the increased rating of the 21st century skills of the learners, the data revealed that the enhanced module had a positive impact towards the general outcome of the learners on their 21st century skills and performance.

**3.8 Comparison in the 21st Century Skills of Students on Original and Enhanced Activities**

**Table 9.** Comparison in the 21st Century Skills of Students (n=5)

|                     | Original Activities | Enhanced Activities |
|---------------------|---------------------|---------------------|
| Mean                | 1.55                | 4.34                |
| Standard Deviation  | 0.30                | 0.22                |
| Mean Difference     | -3.022              |                     |
| SD Difference       | 0.680               |                     |
| t-value             | -10.880*            |                     |
| p-value             | 0.000*              |                     |

* significant at 0.05 level
Table 9 shows that there is a significant difference between the 21st century skills of students on original and enhanced activities on collaboration, skilled communication, real-world problem-solving and innovation, self-regulation, use of ICT, and knowledge construction since the p-value is less than 0.05 level of significance. And as shown in figure 5 the mean ratings of the learners have increased and have developed their 21st century skills. This means that the 21st century skills are acquired more by the students in the enhanced activities than in the original activities. Thus, null hypothesis number 2 is rejected.

As defined, impact refers to the general outcome of the learners based on their ratings of the 21st century skills and performance. The data show the impact of the enhanced module considering that the students’ performance had improved, and they developed 21st century skills significantly.

4. Conclusions and Implications
The researcher concludes the following based from the data discussed.

1) The results of the ratings of the experts and end users suggest that the module on gas laws with seven activities must be enhanced in such a way that it can improve learning and provide conceptual understanding to students and develop 21st century skills.

2) The seven (7) grade 10 gas laws module did not meet the standards of 21st century skills. Thus, these activities need enhancement based on the baseline data obtained from the first objective.

3) The enhancement of the DepEd gas laws module helped the students acquire 21st century skills required and develop conceptual understanding. Thus, it is more beneficial to learners if the chemistry modules will utilize the 21CLD Rubrics.

4) The content validity of the enhanced module was checked the experts. It underwent series of revisions in incorporating their corrections. The readability of the enhanced module is fairly easy to read. The Student involvement Index is 88, which means that 88% of the students were more involved in the enhanced module. Thus, the enhanced module can provide avenue for learners to participate in the activities with correct concepts and readable learning materials.

5) The enhanced activities have high ratings and are more beneficial to students because it can develop the 21st century skills of the students. And the comments of the experts and end users are positive towards the utilization of the module. Thus, the enhanced gas laws module can be beneficial for both students and teachers in the teaching learning process.
6) The mean scores of all the activities showed that the students who used the enhanced activities have higher ratings compared to students who used original activities. Thus, it is an evidence that the enhanced module can provide better output than as compared to the use of the original DepEd module.

7) There is a significant difference between the pretest and post test result in both control and experimental groups since the p-value are less than 0.05 level of significance. This means that the students in both control and experimental groups perform better in the posttest than in the pretest as observed also in their mean scores.

8) There is no significant difference between the 21st century skills of students in the original and enhanced activities since the p-value is greater than 0.05 level of significance but the mean rating values of enhanced activities are higher compared to the mean ratings of the original activities. This means that the 21st century skills of the learners had been developed using the enhanced K to 12 modules as compared to the original activities.

9) The results show that the impact of the enhanced module is students’ better performance and the acquired 21st century skills.

10) The study provides basis in designing STEM education lesson plan on topic gas laws.

5. Recommendations
   Based on the conclusions in the study, the following are the researcher’s recommendations.

1) STEM Education lesson plan be developed to enrich student learning and conduct investigation on its effect to students’ experimental learning.

2) All DepEd chemistry modules may be rated using the 21st Century Learning Design Rubrics so that enhancement could be done to help students acquire the 21st century skills.

3) The contents of the DepEd learning modules may be checked thoroughly to avoid students’ misconceptions about the lessons.

4) It is also suggested that the reading ease and students’ involvement index of the original module be improved. The Student Involvement Index should be high before it will be disseminated to the different DepEd schools all throughout the country.

5) Other modules in Physics, Biology, and other field of science must be evaluated and enhanced to incorporate and develop 21st century skills.

6) The DepEd textbook committee may be revitalized to ascertain the quality of the module to be used by the students and the utilization of the 21st Century Learning Design rubrics that would help develop the 21st century skills of the learners.

7) Train the teachers on how to develop activities that utilized 21st Century Learning Design Rubrics that would help them develop the 21st century skills among students.

8) The school principals should initiate in utilizing the 21st Century Learning Design Rubrics among teachers to attain high performance level of the students.

9) Based on the results, the researcher recommends the enhancement of other science learning materials and consider the impact that it can contribute to better the performance of students as well as having them acquire 21st century skills.

6. References
[1] Alberta Education (2010). Inquiry-Based Learning. Retrieved from: http://galileo.org/teachers/designing-learning/articles/what-is-inquiry/

[2] Boyore. R. Y. & Cabili. M. C (2009), Identification of Difficult Topics in Chemistry as Perceived Students and Teachers in Private and Public Schools, Undergraduate Thesis. Iligan City: MSU-IIT

[3] Casner-Lotto J, Barrington L. (2010). Are they really ready to work? Washington, DC: Conference Board, Partnership for 21st Century Skills, Corporate Voices for Working Families, and Society for Human Resource Management; 2006. Retrieved from: http://www.conference-ard.org/Publications/describe.cfm?id=1218

[4] Deloitte Development LLC the Manufacturing Institute. 2005 skills gap report—A survey of the American workforce. Washington, DC: Deloitte

[5] Development, LLC ;2005. Retrieved from: http://www.nam.org/~media/AboutUs/ManufacturingInstitute/ innovationreport.ashx
[6] Farasi, M. (2016). Developing the 21st Century Social Studies Skills Through Technology Integration. Retrieved from http://files.eric.ed.gov/fulltext/EJ1092803.pdf

[7] Guarin, R. B. (2016). The Effects of Enhanced Earth Science Module in the Collaboration Skills Using the 21 CLD Rubrics for Collaboration (Unpublished Master’s Thesis). MSU-IIT, Iligan City.

[8] Ledward, B. C., and D. Hirata. 2011. An overview of 21st century skills. Summary of 21st Century Skills for Students and Teachers, by Pacific Policy Research Center. Honolulu: Kamehameha Schools—Research & Evaluation.

[9] Microsoft Partners in Learning. (2012). “21st Century Learning Design” Retrieved from: http://fcl.eun.org/documents/10180/14691/5.3x++21cld+learning+activity+rubrics+2012.pdf?e240da11-07c2-4633-a86e-06c12f00d8ad?version=1.0

[10] Pacific Policy Research Center. (2010) 21st Century Skills for Students and Teachers. Honolulu: Kamehameha School, Research and Evaluation Division. Retrieve from: http://www.ksbe.edu/_assets/spi/pdfs/21_century_skills_full.pdf

[11] Romulo, J. A. (2017), The Impact of Junior High School Chemistry Spiral Progression on Students’ Self-Efficacy and Performance, (Unpublished Master’s Thesis). MSU-IIT, Iligan City.

[12] SRI International. 2012. 21st Century Learning Design Retrieved from: http://fcl.eun.org/documents/10180/14691/5.3x++21cld+learning+activity+rubrics+2012.pdf?e240da11-07c2-4633-a86e-06c12f00d8ad?version=1.0

[13] Science Learners’ Material (2013). Department of Education Manila Philippines.ISBN: 978-971-9990-58-1. Retrieved from: www.deped.gov.ph

[14] Sutaphan, S. Yuenyong, C. (2019). STEM Education Teaching approach: Inquiry from the Context Based. Journal of Physics: Conference Series, 1340 (1), 012003

[15] EJ Villaruz, MCF Cardona, AT Buan, MB Barquilla, C Yuenyong (2019). Ice Cream STEM Education Learning Activity: Inquiry from the Context. Journal of Physics: Conference Series, 1340 (1), 012092 (SCOPUS)

[16] MJQ Orongan, EB Nabua, MB Barquilla, AT Buan, EN Inutan, C Yuenyong (2019). Cognitive attributes, physical and psychosocial aspects of learning environment: Its relationship to learners’ chemistry achievement. Journal of Physics: Conference Series, 1340 (1), 012068

[17] RM Guarin, AT Buan, E Malicoban, MB Barquilla, C Yuenyong (2019). Formulating Refreshment Drink Activity Utilizing STEM Education for Grade 8 Learners. Journal of Physics: Conference Series, 1340 (1), 012078