

# Integrating UNESCO ICT-Based Instructional Materials in Chemistry Lessons

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**Abstract**—This study determined the effectiveness of the lessons in Chemistry integrating UNESCO ICT-based instructional material on the achievement of Chemistry students at Central Bicol State University of Agriculture. It aimed to identify lessons that may be developed integrating UNESCO ICT-based instructional materials, determine the effect of the developed lessons using the material on: conceptual understanding; science process skills; and attitude towards chemistry and gather insights from the experiences of the students and teacher.

The study used the single group pretest and posttest experimental design. Descriptive, quantitative and qualitative techniques were also utilized. Quantitative data were taken from the pretest-posttest results on the Test on Conceptual Understanding, Science Process Skills and Chemistry Attitudinaire. Qualitative data were drawn from the experts' assessment of the developed lessons and research instruments, and the insights of students and teacher.

The developed lessons integrating UNESCO ICT-based instructional materials were Atomic Model and Structure, Periodic Table of Elements, Chemical Bonding, and Balancing Chemical Equation. These lessons increased the conceptual understanding of the students by topic and skill from very low mastery to average mastery level. The students have slightly improved along the different science process skills. After teaching the lessons, the students' attitude also improved. The students became more motivated and interested in Chemistry and the lessons were student centered and entailed teacher's competence and flexibility in computer use.

**Keywords** – ICT, integration, achievement, instructional material

## I. INTRODUCTION

Through the years, education in the country has undergone paradigm shifts and modification to strengthen and attune it to the changing environment and keep up with the latest developments in the field, as well as to develop high level of literacy among Filipino students to enable them to participate actively and effectively in modern society. Several studies have shown that Philippine education needs an immediate attention and healing to ensure and sustain quality education. Science education is no exception. Most often, students perceived science as a hard and complicated subject. According to DepEd, Science obtained the lowest percentage of 40.53% as compared with other core subjects in the high school in the National Achievement Test in 2011-2012. It shows that students indeed encounter difficulties in this subject. In

the TIMSS in 2003 and 2008 results showed that the Philippines ranked 43<sup>rd</sup> out of 46 countries in HS II Science and last of the ten countries in advanced math category, respectively, even with the science high schools only who participated in the study.

According to Lizalde (1990), "the continued deterioration of the quality of education in the country can be ascribed to the grossly inadequate funding sources in both public and private schools". The inadequate funding here implies several teaching and learning problems like poor classroom environment and accommodation, inadequate evaluative device and most importantly inadequate teaching aids and device.

The lack of instructional materials is one of the reasons identified as contributory to such condition. That is why there is an extensive effort to alleviate the low performance of students in Science and other subjects by the government to come up with materials

that are readily available for use by students. The search for network and linkages with funding agencies throughout the globe with the same interest of providing resources and avenues for students' improved academic achievements is also continuous.

Ramirez (2006) cited that many educators claimed that strategy and instructional materials are indispensable tools in the teaching and learning process. Maximum use of senses in the educative process proved to ensure better understanding of lessons. Sutaria (1990) claimed that children learn better when they are happy and free to experiment and discover. She looked forward to seeing innovative and adventurous teachers who do not stick to the monotonous question and answer technique but explore new exciting strategies and who no longer resort to regressive feeding strategies that immobilize rather than develop the child's intellect.

On the other hand, the use of instructional materials that relate to technology is of great help to improve the learning of students because they find it more creative, interesting and easy to recall unlike the traditional way of "chalk and talk". Today's learners prefer activities where they can interact, express themselves and get immediate feedback. Educators need to accept that students of the present generation are techno-natives who can easily navigate through new technology. They have been highly exposed to various forms of media and technological tools, multi-sensorial stimulation, multi-tasking, "instant" processes, "instant" products and a barrage of information from various sources-both accurate and inaccurate (Tan, 2007).

Haddad (2002) asserted that, "ICTs are powerful tools when used properly because they can improve motivation and engagement in the learning process, can develop multiple intelligence through multimedia presentation of materials and they make it easy to understand abstract concepts by making them more concrete". Chemistry being viewed as abstract science can be taught using ICT to make such abstract concepts more concrete and ensure proper motivation and engagement of students in the learning process.

Chemistry as a physical science subject for many students is difficult and lacking relevance. Personal observations and several studies showed that more than majority of students lack motivation and interest in the subject. Hence, this resulted to low achievement in chemistry especially among high school students. The same scenario created an abrupt decrease of college students taking physical science subjects as their major courses due to numerous units involving chemistry

related subjects. More often, this can be attributed to the nature of topics which were odd and lack relevance in the daily activities of the students. Such topics on chemical formula and equations, the structure of atom, periodic table of elements and chemical bonds are foundation of Chemistry that need to be given emphasis as reported by Chemistry Performance Report of SPM 2003( Laporan Prestasi SPM, 2003).

The use of ICT based instructional material in teaching chemistry may make a turn-around in the present low academic achievement of students in science particularly in Chemistry knowing that integration of technology in teaching the subject may be more appealing and relevant to the present generation of learners.

## II. OBJECTIVES OF THE STUDY

This study aimed to determine the effectiveness of the Lessons in Chemistry integrating UNESCO ICT-based instructional materials on the achievement of Chemistry students at Central Bicol State University of Agriculture Laboratory High School for School Year 2012-2013.

The specific objectives were: develop lessons in Chemistry integrating UNESCO ICT-based instructional materials; determine the effect of the developed lessons using UNESCO ICT-based instructional materials on conceptual understanding, science process skills and attitude towards chemistry as a subject; determine the insights drawn from the experiences of the students and teacher exposed to the lessons integrating UNESCO ICT-based instructional materials.

## III. MATERIALS AND METHODS

This study determined the effectiveness of the developed lessons in Chemistry integrating UNESCO ICT-based instructional materials on the achievement of Chemistry students at Central Bicol State University of Agriculture Laboratory High School of school year 2012-2013. It used the single group pretest and posttest pre-experimental design. Descriptive, quantitative and qualitative techniques were employed in the study. Quantitative data were gathered through the use of the pretest-posttest results on the Conceptual Understanding Test in Chemistry, Science Process Skills Test and Chemistry Attitudinaire. Qualitative data were drawn from the experts' assessment of the developed lessons

and research instruments and journal entries of students and teacher.

Descriptive statistics like frequency count, percentage and weighted means were employed to quantify and interpret the data gathered to attain the objectives set in the study. In data gathering and tallying, simple frequency distribution and percentage were utilized. Item analysis was used to determine the items that were included in the final draft of the Conceptual Understanding Test in Chemistry.

The effectiveness of the lessons developed integrating UNESCO ICT-based instructional materials relevant to conceptual understanding, science process skills and attitude was measured through the mean difference, mastery performance level and the change in performance in the pretest and posttest of the student-respondents.

#### IV. RESULTS AND DISCUSSIONS

**Developed Lessons Integrating UNESCO ICT-Based Instructional Materials.** The researcher developed four major lessons, along: Atomic Model and Structure, Periodic Table of Elements; Chemical Bonding; and Balancing Chemical Equation. These topics were part and given emphasis in the UNESCO ICT-based instructional materials which also included topics in math and other science subjects. The development of lessons along these areas is in response to the global call of enhancing the teaching-learning process through the use of technology, particularly, ICT.

The 2005 Education for All (EFA) Global Monitoring Report highlights the importance of high quality education as follows:

*The achievement of universal participation in education will be fundamentally dependent upon the quality of education available. For example, how well pupils are taught and how much they learn, can have a crucial impact on how long they stay in school and how regularly they attend. Furthermore, whether parents send their children to school at all is likely to depend on judgments they make about the quality of teaching and learning provided – upon whether attending school is worth the time and cost for their children and for themselves.” (UNESCO, EFA Global Monitoring Report 2005, p.28)*

The report also confirms the central role of teachers in any education system, emphasizing that the quality of

education is directly linked to how well teachers are prepared for teaching. In today’s world, teachers need to be equipped not only with subject-specific expertise and effective teaching methodologies, but with the capacity to assist students to meet the demands of the emerging knowledge-based society. Teachers therefore require familiarity with new forms of information and communication technology and need to have the ability to use that technology to enhance the quality of teaching and learning. The UNESCO ICT-based instructional materials were developed to serve this purpose. The materials have many features that can catch the attention of the students and ensure that the learning is achieved to its full extent. It contains the following resources: Quizzes and tests, which assess the understanding of content in various formats and game formats; Simulation, inputs data to change the variables and observe changes; Animation, which shows actual processes through graphics; Video clips, for demonstrations purposes; Tools, which assists students to perform some work (e.g. Essay helper); Tutorial programmes, which teach concepts and test; and Drill and practice, which evaluates the students’ learning outcome.

Further, the material features the use of different approaches to ICT integration. These include: Student-centered approach, Teacher-presented approach, and Split-group. In student-centered approach, two or more students explore the relevant resources, answering questions and recording their answers in the activity sheets. Teacher-presented approach is applied if there is only one computer. The teacher demonstrates the learning activities to the whole class. It is very important to get the students involved in the activities and not to turn the lesson into a teacher-talk session. It is important that teachers practice using the materials before the class. In Split-group approach, there are only a few computers in the class. Thus, it is not possible for all students to be working on the computers at the same time. The teacher will have to split the class into groups. Some groups will work on the computers while the others work on non-computer related activities. Teacher must plan well to get every student involved and give sufficient time for all students to have a chance on working at the computer with the learning resources.

Table 1 shows the integration of the instructional materials which include the lesson, ICT integration, point of integration, target competencies, varied teaching strategies employed and the corresponding science process skills.

Table 1. Integration of the UNESCO ICT-Based Instructional Materials in the Lessons

Lesson	(UNESCO ICT-Based Materials)	Point of Integration	Target Competencies	Teaching Strategies	Science Process Skills
Atomic Models and Structure	-Simulation of the Structure of Atom -Historical Aspects of Atomic Models -Examining Atomic Structure & Ionic bonding	-Abstraction	-Trace the history of the atomic theory -Identify the different atomic models and its structure -Describe the subatomic particles and their locations -Simulate different Atomic Models -Relate the importance of the discovery of atoms in daily life.	4 A's Role Play Reflective teaching Laboratory activity Games & Simulation	Observing Classifying Communicating
Periodic Table of Elements	-Learning the Elements of the Periodic Table -Periodic Table and Metals -Characteristics of Periodic Table	-Application  -Abstraction	- Identify the chemical and physical properties of elements - Write/Name chemical symbols/elements in the PT - Use the PT in predicting the chemical behavior of elements - Cite the importance of the PT of elements and their basic features as applied in modern technology and other human endeavors - Construct a matrix/table showing the different groups of elements	4 A's Symbo- Game Laboratory Activity Interactive Games	Inferring Predicting Communicating
Chemical Bonding	-Lessons on Ionic Bonding(with 2 <sup>nd</sup> version) -Formation of Ionic Bonds and Covalent Bonds -Game on Covalent Bonding -Simulation to Show Metallic Bonding	-Abstraction	- Identify the different kinds of chemical bonding - Predict elements to form ionic, covalent and metallic bonds -Describe the behavior/movement of electrons when forming ionic, covalent and metallic bonds -Write chemical formulas of ionic and covalent compounds or name the compounds given the chemical formula -Value the benefit of chemical bonding as an initial process in forming products	4 A's Video clip showing Game (Crossword Puzzle) Concept mapping Reflective Teaching Laboratory Activity	Classifying Inferring Predicting Communicating
Balancing Chemical Equation	-Balancing Chemical Equation -Another Approach to Balancing Chemical Equation	-Abstraction	-Identify the vital components/features of a balanced chemical equation -Balance a given chemical equation -Explain the law of conservation of mass as observed in a balanced equation -Predict the resulting product (compounds) of a particular chemical equation -Value the importance of maintaining balance in daily life	4 A's Video clip Laboratory Activity Games Simulation Interactive quiz	Observing Classifying Inferring Predicting Measuring

**Effect of the Developed Lessons Using UNESCO ICT- Based Instructional Materials on:**

**Conceptual Understanding.** The conceptual understanding was measured using the performance level of the students in the teacher-made test in Chemistry administered as pretest and posttest after careful and thorough validation process guided by the experts in the field. As shown in Table 2, the results of the pretest in conceptual understanding revealed that 16 students (36.36%) obtained a very low mastery level, and 28 students (63.64%) obtained a low mastery level. On the other hand, the results of the posttest using the same treatment and set of questions indicated a significant increase in the performance level of the students as compared to the pretest results. The results were: one student (2.27%) obtained “low mastery level”; 37 students (84.09%) obtained “average mastery”; six students (13.64%) obtained “partially close to mastery”.

These results indicated that the use of the developed lessons integrating the UNESCO ICT-based instructional material improved the performance of the students, particularly, in the conceptual understanding of the lessons. Generally, the table shows that the most frequent performance level of the students changed from “low mastery” in the pretest to “average mastery” level in the post test. Such findings were similar to the study of Lea (2009) on the effect of the use of computer simulation on the students’ conceptual understanding, interest in and attitudes towards Chemistry which revealed that the use of computer simulation significantly improved the academic achievement of the students in the experimental group as compared to the control group without exposure to computer simulation and enhanced the students’ interest in and attitude towards Chemistry.

Table 2. Frequency Distribution of Scores and Performance Level in the Conceptual Understanding Test

Percentage Score	Pre Test		Post Test		Performance Level
	Frequency	%	Frequency	%	
96-100	0	0.00	0	0.00	Sound Mastery
86-95	0	0.00	0	0.00	Very Close to Mastery
66-85	0	0.00	6	13.64	Partially Close to Mastery
35-65	0	0.00	37	84.09	Average Mastery
15-34	28	63.64	1	2.27	Low Mastery
5-14	16	36.36	0	0.00	Very Low Mastery
0-4	0	0.00	0	0.00	No Mastery

Though the result showed that no student obtained very close to mastery and sound mastery levels, the improvement in the conceptual understanding of the students in the post test can be attributed to the fact that in the lesson delivery more time was spent in the abstraction part of the lessons where abstract concepts in Chemistry were fixed and clearly explained with the aid of the UNESCO ICT-based instructional materials. Moreover, this result was consistent with the

performance level in conceptual understanding test by topic as shown in the next table.

Table 3 shows the performance level in the Conceptual Understanding Test in Chemistry classified by topic before and after the use of the lessons. In the pretest, the results revealed that the students had a “low mastery level” in the Periodic Table of Elements and Atomic Model and Structure at 24.02% and 16.59%, respectively.

Table 3. Performance Level in Conceptual Understanding Test in Chemistry

Topics	Pretest		Posttest	
	PL	Interpretation	PL	Interpretation
A. Atomic Model and Structure	16.59	Low Mastery	68.03	Partially Close to Mastery
B. Periodic Table of Elements	24.02	Low Mastery	61.82	Average Mastery
C. Chemical Bonding	12.05	Very Low Mastery	38.56	Average Mastery
D. Balancing Equation	13.56	Very Low Mastery	54.24	Average Mastery
<b>OVERALL</b>	<b>16.56</b>	<b>Low Mastery</b>	<b>55.66</b>	<b>Average Mastery</b>

Moreover, the students had a “very low mastery level” in Balancing Equation and Chemical Bonding at 13.56 percent and 12.05 percent, respectively. On the other hand, the results of the posttest revealed that the students had a “partially close to mastery level” in the Atomic Model and Structure at 68.03 percent and “average mastery in the Periodic Table of Elements, Balancing Equation and Chemical Bonding at 61.82 percent, 54.24 percent and 38.56 percent, respectively.

**Science Process Skills.** The effect of the developed lessons integrating the UNESCO ICT- based instructional material on the science process skills was evaluated using the Science Process Skills Test (SPST). This instrument measured the different basic skills of the students. These process skills include: observing, classifying, inferring, predicting, measuring and communicating.

Table 3 shows the distribution of students’ mean score in Science Process Skills Test in both pretest and posttest. The mean scores in the SPST was obtained

from the sum of the correct responses obtained by the students per item divided by the number of students who took the test, the mean score per item were grouped together according to their process skills. The results showed that students obtained a slight increase in their scores in the skills of observing, classifying, inferring, predicting, measuring and communicating. Moreover, among the six basic skills, the students earned the highest increase in the mean scores in inferring and predicting with a mean difference of 0.86. This meant that the students have slightly improved along these skills after they used the developed lessons using UNESCO ICT- based instructional material. Such minimal increase implied that a lot of improvement is needed for the development of science process skills. The type of activities that should be provided must give opportunities for students to develop and practice such skills and more time must also be given on these activities not only in the abstraction part of the lessons as done in this study.

Table 4. Distribution of Students’ Mean Score in Science Process Skills Test

Process Skills	Highest Possible Score	Pretest		Post Test		Mean Difference
		Mean Score	%	Mean Score	%	
Basic Skills						
Observing	2	0.55	27.0	0.59	29.5	0.04
Classifying	2	1.56	78.0	1.72	86.0	0.16
Inferring	7	3.11	44.0	3.97	56.7	0.86
Predicting	5	1.50	30.0	2.36	47.2	0.86
Measuring	3	0.48	16.0	0.68	22.6	0.20
Communicating	1	0.34	34.0	0.43	43.0	0.09
<b>Total</b>	<b>20</b>	<b>7.54</b>	<b>38.0</b>	<b>9.75</b>	<b>48.7</b>	<b>2.21</b>

On the other hand, the students had the lowest mean score in observing at 0.04. This can be attributed to the activities related to this skill which only generate responses that measure the low-order thinking skills of remembering and understanding.

This is in line with the findings of Baylon (2013) who attributed the development of these lower order thinking skills to the common use of the lecture format as the primary method of teaching and learning. This learning strategy is popular for content delivery in the basic education, but proven not to promote active learning or critical thinking on the part of students. Although this is considered as a science process skill, it should not be overused since it is both teacher-centered and comes with a strong academic tradition and unfortunately, it does not promote the students’ critical thinking skills. Topics are discussed sequentially rather than critically, and students tend to memorize the

material since the lecture method facilitates the delivery of large amounts of information, hence, defining features and other techniques that facilitate memorizing/recalling thereby developing the low-order thinking skills were utilized. This situation makes the teacher does the talking, questioning and thinking which makes the students become more passive, thus depriving them an opportunity to develop their critical thinking abilities (Maiorana, 1991).

On the other hand, the skills where the students had the highest mean score promote active learning which can make the course more enjoyable for both teachers and students, and, most importantly, it can cause students to think critically. For this to happen, educators must give up the belief that students cannot learn the subject at hand unless the teacher covers it. While it is useful for students to gain some exposure to the material through pre-class readings and overview

lectures, students really do not understand it until they actively do something with it and reflect on the meaning of what they are doing. This is the main feature of the developed lessons integrating the UNESCO ICT- based instructional material.

Furthermore in the study of Baylon (2013), he emphasized that critical thinking is one of the important elements of scientific thinking. Critical thinking is active and organized mental process that realized one's thinking and also considering what others are thinking, practice what were learned, and aims to understand events and circumstances in the environment. There are five basic characteristics of critical thinking. The first one is that critical thinking requires being active, the other one is that critical thinking requires to be independent, another one is that critical thinking requires open-mindedness to new ideas, more over critical thinking requires to consider the proofs and reasons advocating the thinking, the last one is that critical thinking requires the organization (Ozden, 2003).

**Attitude towards Chemistry as a Subject.** The effect of the developed lessons integrating the UNESCO ICT- based instructional material on the attitude of the students towards chemistry as a subject was determined using the Chemistry attitudinaire. The instrument is consists of 25 items which were evaluated using a five-point Likert scale with one (1) being "strongly disagree" and five (5) being "strongly agree". The questionnaire includes items that asses how the subject interests and stimulates the students; its usefulness to their daily activities; guides their choice of course in college and eventually work in a chemical laboratory or do Chemistry-related jobs; motivates punctuality in attending the subject; challenges the students to enhance their problem-solving skills; provides a connection of the concepts to real-life situations, particularly in the environment; helps in understanding the world better after learning the concepts; motivates the students to surf related websites, watch Chemistry-related fiction and non-fiction movies and TV shows, perform laboratory exercises in Chemistry, work with chemicals and Chemistry apparatus in the laboratory room, make Chemistry projects more interesting and challenging, prepare assignments and reports in Chemistry, participate in Chemistry-related learning activities, and to answer Chemistry enrichment exercises; encourages the students to appreciate Filipino and foreign chemists who developed materials for human benefit, read Chemistry researches/studies and discuss how these

researches help improve the quality of life; and how the subject and the teacher encourage the students to study.

The pre-survey of students' attitude was conducted before teaching the developed lessons integrating the UNESCO ICT- based instructional materials. Before using the newly-developed lessons, the students' attitude obtained an overall mean score of 3.63 which is interpreted as positive. This meant that the students have affirmation or acceptance of the subject which inadvertently promote the different science process skills which contribute in developing scientific thinking. This can be attributed to the role played by the teacher in motivating the students to appreciate the importance of the subject. The academic performance of the students and their attitude towards the subject is affected by the teacher's instruction, thus teachers play important role in students learning process. Undeniably, the attainment of the learning goals depends to a great extent on the ways teacher plan and designs the lessons including the activities that promote desirable cognitive, affective and psychomotor skills of the learners. More so, the teaching-learning resources and instructional materials used by the teacher and the teacher's competence in the use of those devices in classroom instruction contribute also in ensuring quality and meaningful students' learning.

This is in line with the study of Salandanan (2002) who stressed that one very important feature in developing children's academic performance and attitude is the skill in improving the daily performance of the learners inside the classroom through varied techniques and strategies. It is in the classroom where instructional supervision is most needed and can be controlled. Teacher facilitates learning where the students are given the opportunity to take part in the teaching-learning process.

After teaching the developed lessons integrating UNESCO ICT- based instructional materials, the students' attitudes remained positive but with an increase mean score of 4.13. This meant that using the developed lessons, the students' interest were stimulated and they were motivated to actively participate in the teaching-learning process.

**Insights Drawn from the Experiences of Using the Developed Lessons Integrating the UNESCO ICT-based Instructional Materials.** The highly developing technology allows multimedia information to be presented variously and vividly, and the speedy connection of internet allows people to gain information easily and swiftly. Thus, the application of multimedia technology in classroom is very pervasive and is

integrated into different levels of education in classroom teaching. The idea of integration of multimedia in teaching is to connect different multimedia elements, such as text, image, audio, animation, and video, to create digital teaching materials and to apply it in classroom teaching, which intends to improve the quality of teachers' teaching and students' learning.

Besides the above cited importance of ICT and other forms of multimedia technology in education and in classroom instruction, this study provided some insights on the use of the developed lessons integrating the UNESCO ICT-based instructional materials along motivation, use of technology, students' feelings towards ICT, design of the lesson, teacher competence and preparedness on ICT integration.

## V. CONCLUSIONS AND RECOMMENDATIONS

The developed lessons integrating the UNESCO ICT-based instructional materials were: Atomic Model and Structure, Periodic Table of Elements; Chemical Bonding; and Balancing Chemical Equation. These lessons increased the conceptual understanding of the students by topic and skill from very low mastery to average mastery level. The students have slightly improved along the skills of observing, classifying, inferring, predicting, measuring and communicating after the lessons. The students' attitude also improved.

The students became more motivated and interested in learning the different topics in Chemistry and the lessons were student centered and entailed competence and flexibility in computer use on the part of the teacher.

These developed lessons should be utilized and adopted by Chemistry teachers to increase conceptual understanding and develop the science process skills of the students. However, more opportunities to practice science process skills of the students should be provided by giving activities that promote such skills and more time should be spent in these activities. Teachers should continue to develop lessons integrating UNESCO ICT-based instructional materials or other media-related materials using the inductive method and the 4A's approach in teaching science, which include Activity, Analysis, Abstraction and Application. Implement the approach in teaching other subjects and compare its effectiveness against the traditional method. ICT integration can be done in the different parts of the lesson as the teachers find it appropriate. Teachers, administrators, and education professionals should promote technology integration in classroom

instructions to understand the issues which accompany this process.

Administrators must provide a venue or opportunities for the teachers to develop lessons and materials that integrate prevalent technology. They should support and encourage teachers to attend retooling and retraining to upgrade competencies on the use of media technology so they could be more creative and innovative. Moreover, the regular evaluation of teachers should also include an assessment of their competencies in ICT integration.

Further study may be conducted to include the effectiveness of the lessons in developing the critical thinking skills of the students.

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