Enhanced 7E Instructional Model towards Enriching Science Inquiry Skills

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Article Info	Abstract
	This study enhanced the 7E instructional model towards enriching the science inquiry skills of senior high school learners in General Chemistry 1. A total of 136 Grade 12 learners enrolled in the Science, Technology, Engineering, and Mathematics (STEM) strand participated in the study. The study was composed of three phases. In Phase I, the generated themes nature of topics, learning environment, learner-related and teacher-related issues were found to be the causes of difficulty in science inquiry skill enrichment. The learners' meaningful learning experiences during the process were encapsulated in Phase II. Finally, Phase III used the generated themes in the enhancement of 7E instructional model promoting inquiry-based and constructive learning among senior high school learners.

Introduction

To adapt to this ever-changing and fast-paced society improvement and sustainability of Philippine quality education is an utmost priority (Durban & Catalan, 2012). With the establishment of K to 12 curriculum, the Department of Education hoped to solve the country's needs (Abulencia, 2015) and to keep up with the global educational reform (Belecina & Ocampo, Jr., 2018). Likewise, learners are taught to think scientifically, design scientific inquiry, interpret data and evidences, and draw conclusions (van Uum et al., 2017). This encompasses science education's goal in the country's current curriculum. However, with the unprecedented events brought about by the COVID-19 pandemic schools forcefully closed its operation on March 2020 to contain its spread which may affect the welfare of learners, teachers, and educational stakeholders inadvertently. This compromised the Department of Education's plans to open the classes every June of the year. As a result, the department released DepEd Order No. 12, s. 2020 establishing the adoption of Basic Education Learning Continuity Plan (BE-LCP) that contains sets of educational interventions through necessary K-12 curriculum adjustments, alignment of learning materials, deployment of multiple learning delivery modalities, provision of trainings for teachers and school leaders, and proper orientation of parents/guardians. In general, majority of the learners preferred modular distance learning (MDL) as they find it difficult to cope up with the challenges posed by online distance learning such as lack of internet and gadgets to use. However, empirical observations and interviews with the parents/guardians depicted that most of the learners find it difficult to learn the concepts in the module due to lack of teacher guidance and facilitation for learning.

Consequently, Science, Technology, Engineering and Mathematics (STEM) strand of senior high school program under the K to 12 Basic Education Curriculum which is designed to produce secondary level graduates

capable to take science, research, mathematics, and engineering-related courses in tertiary level faced the same problems in delivering quality education in the New Normal. They are expected to be the next frontier of scientifically-inclined professionals for the country (Caballero & Cabahug, 2015). Thus, the curriculum is purposively designed for mathematics and science-inclined learners as answers to the long-decade problem of low number of mathematics and science practitioners (Rabacal & Alegato, 2017). It was pointed that the low science professionals may be attributed to the poor academic performance of students in mathematics and the low inquiry skill levels of learners in Science that hinders them to excel in science-related endeavors (Chu et al., 2016). The decline in the interest in Science along with insufficient instructional materials affect the progress of the discipline (Hulleman & Harackiewicz, 2009). One of the subjects in senior high school which experienced these dilemmas is General Chemistry 1 which is a specialized subject of the said strand in the senior high school program.

In the education perspective, the evolution of 7E instructional model is the product of collaborative ideas brought about by constructivist and inquiry-based learning approaches in science teaching (Suardana et al., 2018). Williams (2017) emphasized Dewey's ideas about inquiry as the starting point to enrich skills such as creativity, communication, ICT, literacy, and numeracy needed in the modern era. Consequently, science curriculum implements inquiry-based learning in order to create science-oriented learners with the necessary science process skills (Chiang et al., 2014). However, Ješková et al. (2018) found that the senior high school learners' inquiry level remain low. This is because they are not involved in inquiry activities despite finishing elementary and junior high levels. To solve the existing problem, science teachers need to adjust their teaching practices on how their students learn in the 21st century. To implement intensive learner-centered and inquiry-based strategies towards learning, Hennessy et al. (2007) and Scott et al. (2011) stressed the implementation of the constructive, collaborative, integrative, inquiry-based, and reflective (*2C2I1R*) teaching approaches which are essential in developing instructional materials to improve the learning outcome and to address the learners' needs. Quality education means empowered learning and serves as basis for the implementation of the instructional model where learners work independently or collaboratively in developing concepts facilitated by teachers (Stohlmann et al., 2012). This, by far, serves as an inspiration to address the greater need to bridge the gap between technology and inquiry as an offshoot to the enrichment of learners' science inquiry skills using innovative instructional material. With the above-mentioned circumstances, the study was conducted to solve the existing problems and attain the benefits of an enhanced 7E instructional model with integration of the technology-based instructional material in General Chemistry 1.

Theoretical Framework

The use of web-based inquiry learning coupled with 7E instructional model is anchored on constructivist learning theory which has emerged as a prominent approach to teaching for decades. The works of Dewey (1986), Montessori (1965), Piaget (1964), Bruner (1985), and Vygotsky (1978) provided historical precedents for constructivist learning theory. Constructivist learning approach as mentioned by Balta (2016) spurred from the idea that learners construct knowledge in an active process where they combine previous learning to the newly acquired one. In addition, Yoders (2014) instigated that the use of constructivist learning cycle models in

science teaching affects a particular science course. This happens as it equips content of the courses, proliferates learners' attention towards courses, guarantees permanent learning, revolutionizes students' prejudgments towards science, and inspires learners in an entertaining and fruitful manner.

Constructivist approach as Samaresh (2017) mentioned helps in achieving a meaningful learning in science concepts among the secondary learners. Further, Schcolnik and Abarbanel (2006) described constructivists as they view learning as a formation of abstract concepts in mind to represent reality. Learning occurs when a learner constructs internal representations for his/her unique version of knowledge. Adesoji and Idika (2015) emphasized the use of interactive activities in which learners play active roles can engage and motivate learning more effectively than activities where learners are passive. This is natural to expect that self-directed, interactive learning will improve learning outcome with typical less interactive classroom environments relying on instructors, textbooks, and lectures (Dewey, 1986). Individuals are assumed to learn better when they discover things by themselves and when they control pace of learning.

Finally, Eisenkraft (2003) expanded the E instructional model where a problem or a question was provided. They would be required to plan how to solve an experimental problem or to test a hypothesis. Therefore, the students must formulate an investigation procedure to find undetermined outcome by them. It allows the students to think like scientists. Later they acquire knowledge and develop their own understanding of concepts, principles, or even theories. Thus, the researchers combined in this paper the concepts of science inquiry skills, interactive courseware, and the 7E instructional model to fill in the gap.

Research Objectives

This study aimed to enhance the 7E instructional model integrated with the interactive courseware in General Chemistry 1 among Grade 12 learners of Science, Technology, Engineering and Mathematics (STEM) strand, S.Y. 2020-2021.

Specifically, it sought answers to the following objectives:

1. Determine and explain the causes of difficulties in enriching the science inquiry skills in General Chemistry 1 as perceived by teachers and learners.
2. Encapsulate the meaningful learning experiences of learners in enriching science inquiry skills using the developed technology-based teaching material integrated in the 7E instructional model in General Chemistry 1; and
3. Enhance the 7E instructional model integrated with interactive courseware towards science inquiry skills enrichment.

Method

Research Context

This study was conducted in two (2) selected public secondary schools offering the Science, Technology, Engineering, and Mathematics (STEM) strand of the K to 12 Senior High School program in the Schools

Division of Quezon, Philippines. These were Dr. Maria D. Pastrana National High School in Mauban, 4330 and Lutucan Integrated High School in Sariaya 4301. To maintain confidentiality of the data gathered, the school-respondents were coded as public schools A and B. Further, the schools were chosen because they were offering Science, Technology, Engineering, and Mathematics (STEM) strand with two (2) comparable sections. Likewise, the schools pioneered the implementation of STEM strand for several years which qualified them for the study.

Participants

Two (2) groups of Grade 12 students in these schools served as the control and experimental groups. A total of 136 respondents participated in the study with 68 learners each in the control and experimental groups carefully assigned using matching variables. On the other hand, 50 science teachers were chosen purposively from the junior and senior high schools to determine the level of acceptability of the technology-based instructional material in General Chemistry 1.

Measures

Prior to the actual conduct of the study, the researchers assessed the inquiry skills of the respondents using the developed and validated test instrument. In doing so, the researchers followed the careful procedure as mentioned below:

A. Development of pre- and post-level inquiry skills tests. The researchers constructed a 40-item multiple choice assessment in which each item consisted of inquiry skills questions aligned to the target learning competencies with inquiry skill essay per item. This research instrument was pilot tested among select STEM learners who have taken the subject before. During the implementation proper, this research instrument was administered among the student-respondents as pre-level and post-level inquiry skills form of assessment. In addition, the results of the pre-level inquiry skills test served as one of the matching variables to assign the student-respondents into control and experimental groups. Likewise, the significant difference of the posttest mean scores of the student-respondents in the two groups was used to determine the effectiveness of the technology-based constructivist teaching material integrated in 7E instructional model. Moreover, the researchers followed several steps to develop and validate the science inquiry skills test which were as follows:

B. Construction of the Table of Specifications (TOS). The table of specification contained the following elements namely: *Content, Learning Competencies, Number of Hours, Weight, No. of Items, Knowledge (20%), Comprehension (30%),* and *Application (50%).* The last three elements comprised the science inquiry skills determiner alongside with the essay-type question per item. The topics included were embedded in the learning competencies which primarily served as the basis for each test item questionnaire.

C. Establishing the Validity and Reliability of the Science Inquiry Skills Test. The test instrument was composed of 40-item multiple-choice test underwent face and content validation among five (5) Science

curriculum test experts before being pilot-tested to STEM learners who were not part of the study. Upon revision and finalization based on the experts' comments and suggestions, the science inquiry skills test was administered to 50 Grade 12 STEM learners to establish its reliability. The range of scores on the pilot test was 13 to 35 out of 40 test questions. The test mean was 35.56 with a standard deviation of 7.32. On the other hand, Kuder-Richardson (KR) 20 reliability test showed a coefficient of 0.84 indicated as highly reliable. Using item analysis, the researchers identified the items to be revised, rejected, or retained. Necessary revisions of the test material for the final draft were done, accordingly.

Afterwards, the researchers analyzed the respondents' answers on the inquiry skills questions. Furthermore, the researchers assigned the respondents into the control and experimental groups using the matching variables *pre-level inquiry skills scores*, and *Grade 11 general average*. On the other hand, the General Chemistry 1 interactive courseware, to be used as the study's intervention, was crafted as an all-Filipino, locally developed, all-original, and offline-based educational platform available both as web-based and Android-compatible mobile application. With the assistance of an expert software developer, the researchers carried out the development of the interactive courseware's content composed of 5 main parts namely *overview, pre-lab discussion, inquiry skill activity, post-lab discussion*, and *evaluation*. These parts were integrated with the 7E instructional model lesson exemplars for each topic. To ensure the correctness of the content of the application, a content validation among Science teachers and ICT experts was facilitated. Any errors identified during content validation were integrated to improve the application.

For three months, learners in the control group were taught using the conventional teaching while those in the experimental group were supplemented with the General Chemistry 1 interactive courseware integrated in 7E instructional model lesson exemplar. At the end of the experimental stage, the researchers facilitated the post-level inquiry skills test among learners in the control and experimental groups. Lastly, the significant difference between the posttest scores of the two groups was calculated, tabulated, analyzed, and interpreted statistically. A day was allotted for the conduct of focus group discussion and semi-structured interview among selected respondents in the experimental group with regards to their meaningful learning experiences in the utilization of interactive courseware in General Chemistry 1 towards enriching their science inquiry skills. Transcripts were analyzed thematically. This was conducted manually from the initial to final coding stages. These qualitative and quantitative results served as bases in the development of an enhanced 7E instructional model in enriching the science inquiry skills in General Chemistry 1.

Statistical Analyses

Weighted mean was applied to determine the level of teachers' and learners' responses regarding the causes of difficulties in enriching the science inquiry skills. The t-test for independent sample means was used to ascertain the significant differences of the pre-level inquiry skills, and Grade 10 Science grades as a pre-requisite before the actual conduct of the study. The results were used as matching variables in establishing the control and the experimental groups. Likewise, the same statistical analysis was used to determine the significant difference of post-level inquiry skills mean scores between the two groups after the implementation process.

Ethics

An informed consent and protection from harm was given to the participants beforehand. This was done to ensure that the respondents participated in their own will, they would not be harmed, and any data to be gathered in the study were treated with strict confidentiality. Their anonymity was greatly taken with great consideration to keep information in private. In the qualitative phase, it was emphasized that to keep ethical consideration the researchers developed an ethical perspective that was close to one's personal and ethical position, to seek research participants' informed consent, to determine the broader social principles that affect one's ethical stance, and to remain truthful to the answers gathered and maintain composure to the participants to avoid disclosure of the findings.

On the other hand, prior to the conduct of the study letters to the Principal, and parents were disseminated first to inform them about the conduct of the study. The manuscript underwent plagiarism checking to ensure citation and acknowledgement of secondary sources. Finally, the results of the study were willingly shared to all concerned so as to effect positive change and to help beneficiaries disseminate the results for further improvement.

Results

In the study, the researchers sought to address the current problem. These are first-hand experiences of the teachers and learners both in the inquiry process. Hence, a thorough quantitative and qualitative data collection and analyses were instigated. This was done to establish a strong baseline data to provide possible solution to the problems identified. In the first phase, the researchers determined and explained the causes of difficulties in the learners' enrichment of their science inquiry skills.

Phase I. Causes of difficulties in the enrichment of Science Inquiry Skills in General Chemistry 1
Part A. Teachers' and Learners' Responses on the Causes of Difficulties in Science Inquiry Skills Enrichment

Table 1 displays the science teachers' and the students' responses regarding the causes of difficulties in enriching the science inquiry skills in General Chemistry 1 in terms of nature of topics. It reveals that the science teachers and the learners **strongly agree** that the *nature of topics* makes the enrichment of science inquiry skills difficult, which is evident in the average weighted means of **3.46** and **3.42**, respectively. In general, twenty (26) STEM Science teachers felt the need to address the issue on the *nature of topics* as one of the factors/issues hindering the enrichment of learners' science inquiry skills.

On the other hand, sixty-eight (68) STEM learners responded that they developed boredom in Chemistry when faced with unclear concepts to them. Furthermore, they became dissociated with the ideas they found inapplicable to their daily living. These affected their performance and motivation to pursue skills during the conduct of science experiments. Lastly, they considered Chemistry as one of the subjects they found hard to comprehend and they tended to lose sight of asking questions they could not find the answers on their own.

Table 1. Teachers' and Learners' Responses Regarding the Nature of Topics as a Cause of Difficulties in Enriching the Science Inquiry Skills

Statements	Teachers' Responses						Learners' Responses					
	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR
1. Inquiry skills activities are embedded in each Science class.	14	12	0	0	3.54	SA	68	0	0	0	4.00	SA
2. Topics in Chemistry require intellectual thought and discernment.	24	2	0	0	3.92	SA	65	1	2	0	3.93	SA
3. Chemistry has a logical order of topics which makes it easy to grasp the concepts.	26	0	0	0	4.00	SA	66	1	1	0	3.96	SA
4. Topics taught in the class are asked using high level of questioning during assessment in Chemistry.	20	3	3	0	3.65	SA	64	2	2	0	3.91	SA
5. In order to promote inquiry-based learning, Chemistry does not emphasize the use of evidence from the activities in constructing explanations. *	0	0	0	26	4.00	SD	0	1	3	64	3.93	SD
6. Topics are not presented with increasing levels of complexity from one lesson to another using spiral progression towards deeper understanding of key concepts. *	0	0	3	23	3.88	SD	13	0	17	38	3.18	D
7. Some topics in Chemistry require the application of Mathematics which makes the subject more difficult to understand and appreciate. *	8	4	3	11	2.65	D	25	22	12	9	2.07	A
8. Chemistry has topics that seem unclear and complex in nature such as matter; precision and accuracy; atoms, molecules, and ions; stoichiometry; and gas laws.*	5	6	5	0	2.00	A	20	5	18	12	2.40	A
Average Weighted Mean					**3.46**	**SA**					**3.42**	**SA**

Legend: **3.25 – 4.00** Strongly Acceptable (SA)/ Strongly Agree (SA); **2.50 – 3.24** Acceptable (A)/ Agree (A); **1.75 – 2.49** Fairly Acceptable (FA)/Disagree (D); **1.00 – 1.74** Not Acceptable (NA)/ Strongly Disagree (SD)

In connection to the nature of topics, the use of higher order thinking skills (HOTS) questions can improve the quality of science teaching in the future (Darling & Hammond, 2017). This is similar to the study of Seman et al. (2017) that poor critical and creative thinking skills of the learners nowadays hinder their understanding of the concepts and nature of the subject matter. In contrast, Kizilaslan et al. (2012) signified that inquiry learning is essential strategy to those scientifically-inclined individuals. In General Chemistry, learners can succeed if they can think mathematically where calculating numbers in solving problems are necessary (Sugiharti et al., 2019). This is supported by the study of Sopandi et al. (2018) where most of the time learner's mathematical solutions in Chemistry were not checked and even corrected by teachers ahead of time to avoid misconception. Moreover, it was argued that the primary reason why Chemistry remained difficult was its mathematical nature (Kennedy et al., 2014). Thus, the *nature of topics* as one of the factors/issues hindering the enrichment of learners' science inquiry skills. Learners developed boredom in Chemistry when faced with unclear concepts to them. Furthermore, they become dissociated with the ideas they found inapplicable to their daily living.

Table 2 displays the science teachers' and students' responses regarding the causes of difficulties in enriching the science inquiry skills in General Chemistry 1 in terms of learning environment. It displays that the science teachers and the learners generally both **agree** that the *learning environment* makes the enrichment of science inquiry skills difficult to enrich, which is evident in the average weighted means of **2.73** and **2.72**, respectively. In general, twenty-six (26) STEM Science teachers strongly agreed that school has facilities like science laboratory, learning centers, audio-visual rooms, among others, and chemistry classes are held in a conducive learning atmosphere to promote inquiry learning. However, they were not properly utilized and promoted to enrich learners' science inquiry skills. Moreover, they also adhered that the poor background in Chemistry makes the development of inquiry more difficult. These were in congruent to the responses of the sixty-eight (68) STEM learners who honestly explained that they do not have deep prior knowledge about Chemistry concepts. This problem was aggravated by the pandemic where they experienced greater difficulty in understanding the lesson due to lack of hands-on experiences. As a result, there is difficulty in the spiraling of the lessons.

Learning happens when lessons are taught in a learning environment that promotes inquiry. Hence, this contributes not only to get the interests of the learners, but also respond to individual difference. Jocz et al. (2014) found that existing problems on facilities and instructional materials affect in learning the topics in General Chemistry 1. This has negative effect on the achievement of the learning competencies which are necessary in developing their inquiry skills. This is in line with the findings of Orbe et al. (2018) that sufficient facilities are needed in understanding Chemistry in the Philippine K to 12 setting. Truly, having conducive learning atmosphere affects the perspective of learners towards a subject. Observation showed that studying in a place where there is insufficient lighting system, uncomfortable and noisy classroom, and lack of science laboratory equipment and facilities deplete learners' enthusiasm to develop greater understanding in the subject. This is in connection to the findings of Jocz et al. (2014) that the poor background in Chemistry makes the development of inquiry more difficult. Sadly, learners do not have prior knowledge about Chemistry concepts. As a result, there is difficulty in the spiraling of the lessons. Consequently, the researchers felt that deepening of the concepts is sacrificed which adversely affect the next lessons.

Table 2. Teachers' and Learners' Responses Regarding the Learning Environment as Cause of Difficulties in Enriching the Science Inquiry Skills

Statements	Teachers' Responses						Learners' Responses					
	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR
1. Chemistry classes are held in conducive learning atmosphere.	26	0	0	0	4.00	SA	35	32	1	0	3.50	SA
2. The inquiry skill activities provided consist of practical applications.	21	5	0	0	3.81	SA	25	26	17	0	3.12	A
3. ICT-based learning materials are provided to promote 21st century learning.	10	2	14	0	2.85	A	33	22	13	0	3.29	SA
4. School has facilities like science laboratory, learning centers, audio-visual rooms, among others to promote inquiry learning.	26	0	0	0	4.00	SA	61	7	0	0	3.90	SA
5. Poor background in Chemistry during junior high school finds it difficult to promote inquiry learning. *	17	4	3	2	1.62	SA	38	16	2	12	1.82	A
6. Available learning materials are inadequate to support the class. *	11	4	5	6	2.23	A	38	14	7	9	1.81	A
7. Lack of visual presentation makes it difficult to comprehend the lessons. *	15	4	4	3	1.81	A	13	13	35	7	2.53	D
8. Unplanned inquiry skill activities affect the teaching-learning process. *	18	4	3	1	1.50	SA	38	17	3	10	1.78	A
Average Weighted Mean					2.73	A					2.72	A

Legend: **3.25 – 4.00** Strongly Acceptable (SA)/ Strongly Agree (SA); **2.50 – 3.24** Acceptable (A)/ Agree (A); **1.75 – 2.49** Fairly Acceptable (FA)/Disagree (D); **1.00 – 1.74** Not Acceptable (NA)/ Strongly Disagree (SD)

Table 3 describes science teachers' and students' responses regarding causes of difficulties in enriching science inquiry skills in General Chemistry 1 in terms of learner-related issues. It reveals that the science teachers and the learners generally both **agree** that the *learner-related issues* make enrichment of science inquiry skills difficult to enrich, which is evident in the average weighted means of **2.79** and **2.94**, respectively. In general, twenty-three (23) STEM Science teachers exemplified that the advent of modern technology had created changes in the learner's drive to seek knowledge and skills which they could eventually use in future endeavors. In addition, the sixty-eight (68) STEM learners found it difficult to enrich their science inquiry skills due to

several reasons such as the language barrier posed in Chemistry, low mathematical thinking, and low participation in the inquiry process due to pandemic. As a result, they could not adapt to transition of simple to complex Chemistry concepts. This posed a problem to Science teachers on how to encourage the learners to work independently and/or collaboratively.

Table 3. Teachers' and Learners' Responses Regarding the Learner-related Issues as Cause of Difficulties in Enriching the Science Inquiry Skills

Statements	Teachers' Responses						Learners' Responses					
	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR
1. Learners are participative in the inquiry-based skill activities.	1	0	5	20	1.31	SD	33	25	7	3	3.29	SA
2. Learners prefer independent and/or collaborative learning.	23	2	1	0	3.85	SA	47	11	7	3	3.50	SA
3. Learners can easily apply concepts in their daily life.	23	3	0	0	3.88	SA	56	10	2	0	3.79	SA
4. Learners perceive varying concepts in Chemistry easy to enrich the science inquiry skills.	19	5	2	0	3.65	SA	43	12	5	8	3.32	SA
5. Learners cannot enrich their science inquiry skills on their own. *	0	0	12	14	3.54	SD	7	3	13	45	3.41	SD
6. Learners cannot easily understand the scientific "language" used in studying Chemistry. *	25	1	0	0	1.04	SA	10	25	25	8	2.46	A
7. Learners do not have access to innovative ICT-based instructional materials promoting 7E instructional model. *	0	1	2	23	3.85	SD	40	12	6	10	1.79	A
8. Learners have insufficient schema in mathematical application necessary to solve problems in Chemistry. *	23	1	2	0	1.19	SA	36	13	7	12	1.93	A
Average Weighted Mean					**2.79**	**A**					**2.94**	**A**

Legend: **3.25 – 4.00** Strongly Acceptable (SA)/ Strongly Agree (SA); **2.50 – 3.24** Acceptable (A)/ Agree (A); **1.75 – 2.49** Fairly Acceptable (FA)/Disagree (D); **1.00 – 1.74** Not Acceptable (NA)/ Strongly Disagree (SD)

Rotgans and Schmidt (2011) found that independence and engagement of learners in an inquiry-based learning promote cognitive structure. In turn, Science is developed not just to produce learning but rather to engage learners in the learning process. This can only be realized if the learners are enjoying their works independently

or collaboratively. Havice et al. (2018) found that poor study habit added with the spoon-feeding done by the teachers make them more passive. In addition, learners do not actively participate in the accomplishment of inquiry skills activities due to absence of interest, motivation, and enthusiasm. This affects the absorption and application of Chemistry concepts in real life situation (Cetin-Dindar & Geban, 2011). They reiterated that Chemistry remains confusing among the learners due to scientific language barrier. This might be expected when scientific context is taught in its technical aspects. In reality, learners are no longer fond of developing their vocabulary in the second language, and more so, in Science-related subjects. Likewise, Ralph and Lewis (2018) stated that poor mathematical skills increase the difficulty of Chemistry Incidentally, the researchers had observed that some learners tend to use their mobile phones during classroom discussion. It prompted him to develop a supplementary material that can assist the learners to easily access information at their own disposal. Sarac (2017) recommended the integration of 7E instructional model in the development of ICT-based material to address complex ideas in Chemistry. This, in turn, leads to openings an avenue of learning where learners learn the concepts seamlessly.

Table 4 shows the science teachers' and students' responses regarding the causes of difficulties in enriching the science inquiry skills in General Chemistry 1 in terms of teacher-related issues. It reveals that the science teachers and the learners both **agree** that *teacher-related issues* make the enrichment of science inquiry skills difficult to enrich, as shown in the average weighted means of **3.01** and **2.82**, respectively. In general, twenty-six (26) STEM Science teachers stated that mastery of the subject matter was necessity to execute the lessons well. In addition, they strongly recommended that teachers had to be continuously upskilled and reskilled to address the learners' needs in the New Normal. However, they found it difficult to provide the union of 7E instructional model and technological tools due to a lot of circumstances. Thus, the sixty-eight (68) learners believed that they did not just learn through memorization by remembering facts and concepts perceived during lecture, discussion, and the use of textbooks copied, read, or recited in front of the class. As such, they were demanding to show the concepts in the form of ideas for lifelong learning.

Agogo and Onda (2014) found that teachers' qualification and students' perceived difficult concepts in Chemistry have no relation at all. However, they recommended that teachers must be professionally qualified to teach the subject to help the students learn Chemistry more effectively. In addition, Sadler et al. (2013) stated that half of the teaching workforce in secondary and tertiary levels are not specialized in the discipline. Further, Orbe et al. (2018) concluded that the Chemistry instruction is realistic, changing, and creative which requires competent and highly qualified teachers. It can be quoted that "spiraling of Chemistry concepts is learner-centered, advanced, and sophisticated yet it is not concentrated and extensive" (Orbe et al., 2018). Thus, teachers play crucial role in the implementation of a successful inquiry-based learning. It requires students to realize the full potential to develop inquiry skills and appreciate the importance of learning every concept for lifelong learning. Shift from traditional to inquiry-based teaching necessitates teachers to innovate ways on how to enrich learner's meaningful experiences (García-Carmona et al., 2017). Inevitably, this is supported by Čipková & Karolčík (2019) who reiterated that teachers have to give considerable attention on how to develop the learners' science inquiry skills in their science lessons to guide them in applying concepts learned in real life situations.

Table 4. Teachers' and Learners' Responses Regarding the Teacher-related Issues as Cause of Difficulties in Enriching the Science Inquiry Skills

Statements	Teachers' Responses						Learners' Responses					
	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR	4 (SA)	3 (A)	2 (D)	1 (SD)	WM	DR
1. Teachers have adequate pedagogical content knowledge in Chemistry.	22	4	0	0	3.85	SA	48	15	2	3	3.59	SA
2. Teachers apply constructivist approach in delivering the lessons.	18	4	4	0	3.54	SA	12	15	10	31	2.12	D
3. Teachers provide complete explanations about the concept during abstraction.	22	4	0	0	3.85	SA	37	31	0	0	3.54	SA
4. Teachers act as facilitator by letting the learners work independently and/or collaboratively.	12	13	1	0	3.42	SA	12	46	5	5	2.96	A
5. Teachers do not promote the use of 7E instructional model in facilitating an inquiry-based learning in the classroom. *	0	5	9	12	3.27	SD	6	13	26	23	2.97	D
6. Teaching Chemistry still practices conventional teaching approach (lecture, recitation, slide deck presentation, among others).	17	9	0	0	1.35	SA	25	10	13	20	2.41	A
7. Spiral progression approach is not practiced in the delivery of Chemistry lessons without any connection of the lessons formerly learned to the present ones. *	0	1	9	16	3.58	SD	11	3	14	40	3.22	D
8. Use of innovative teaching materials in Chemistry is not practiced in order to uplift learner's interests and motivation in the subject. *	21	4	1	0	1.23	SA	47	2	6	13	1.78	A
Average Weighted Mean					**3.01**	**A**					**2.82**	**A**

Legend: **3.25 – 4.00** Strongly Acceptable (SA)/ Strongly Agree (SA); **2.50 – 3.24** Acceptable (A)/ Agree (A); **1.75 – 2.49** Fairly Acceptable (FA)/Disagree (D); **1.00 – 1.74** Not Acceptable (NA)/ Strongly Disagree (SD)

Henceforth, this calls for an abrupt decision to address the problem with regards to the enrichment of the learners' science inquiry skills which are prerequisite to the tertiary courses in science, technology, engineering, and mathematics disciplines. In general, the *nature of topics, learning environment, learner- and teacher-related issues* were deemed to be the root causes of difficulty in the enrichment of science inquiry skills among Grade 12 learners in General Chemistry 1. It was found that the dominant aspects underlying these root causes

were the learners' difficulty in creating connections between the previous and present lessons, integration of mathematical concepts in the subject, and poor critical and creative thinking skills of the learners magnified further by the pandemic situation. In addition, the poor utilization of Science equipment in the inquiry learning process which was even a greater problem as learners did not attend the school physically. Lack of access to technologically available materials and lack of collaborative learning resulted to low motivation and participation among the learners. Lastly, teachers who were incapable to create connection among technological tools, inquiry learning, and the 7E instructional model decreased the inquiry learning in the process.

Part B: Challenges of Science Inquiry Skills Enrichment

The generated themes from the coding analysis (see Figure 1) summarized these factors identified to be affecting the science inquiry skills, education stakeholders such as teachers, learners, parents, school administrators, curriculum developers, and the national government are facing challenges to take effect the goal of providing enabling environment developing 21st century society (Jocz et al., 2014).
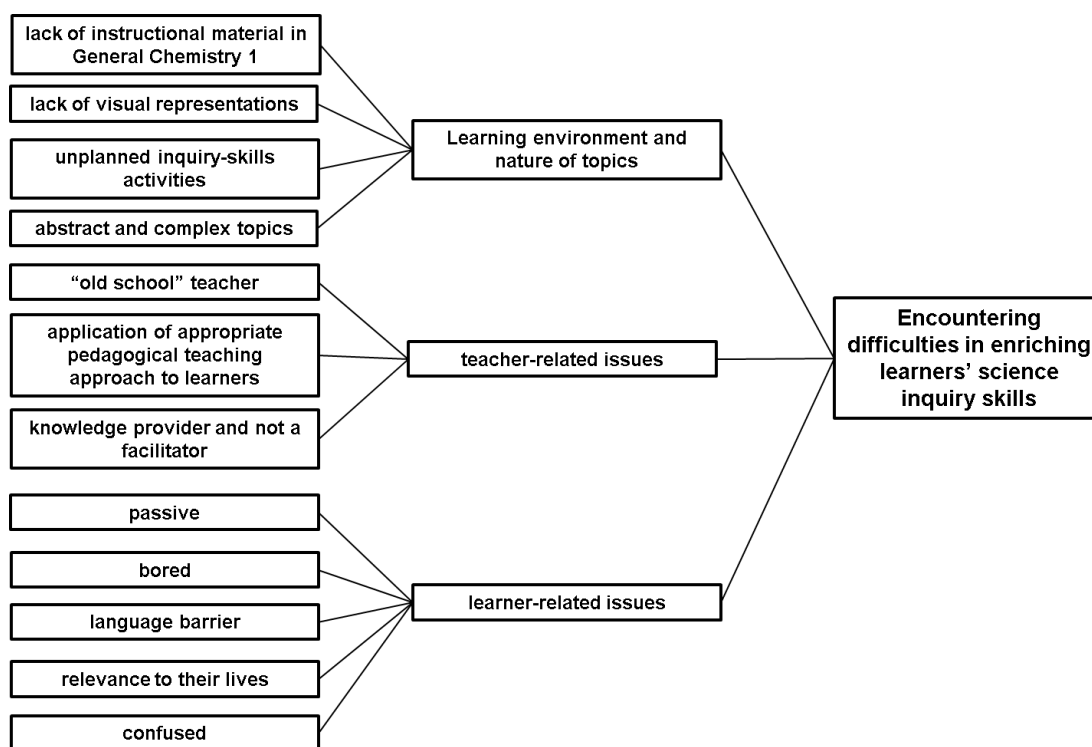

Figure 1. Encountering Difficulties in Enriching Learners' Science Inquiry Skills

Empirically, asking questions is innate to a child. This can be readily observed when one is curious about the things around. In turn, a child learns to investigate until coming up with a solution. Likewise, teachers should develop ways or materials that will enable the learners to enrich their inquiry skills through self-assessment (Zimmerman & Klahr, 2018). Learners can construct their own learning. In addition, they have the tendency to appreciate things when they learn it though first-hand experience. Morally, Orbe et al. (2018) emphasized that the inquiry-based learning is employed in Chemistry instruction in the K to 12 curriculum. Scientific values should be sought to develop along the process. Thus, it engages learners to become motivated, collaborative,

independent, and innovative individuals capable of answering their own queries through investigation. The researchers thought of bringing change in addressing identified causes of difficulties in enriching science inquiry skills in General Chemistry 1.

Phase II. Encapsulation of learners' meaningful learning experiences in enriching their science inquiry skills

With the advent of Industrial Revolution 4.0, the global education sector is focusing more on digital literacy to promote learning in schools (Dewi et al., 2019). As part of globalization and modernization, the challenge among teachers and other education stakeholders lies on the use of available technology to capacitate the learners in creating their own meaningful learning experiences that will enrich their 21st century inquiry skills (Gupta et al., 2015). Chemistry, one of the natural science disciplines, requires learners to apply concepts learned in the classroom to their real-life situations. Thus, technology can be tapped to develop Chemistry learning materials readily available in their mobile phones where learners of today are too passionate about (Shin, 2015). Innovation in the field of Chemistry education must be realized to increase learners' motivation which will result to greater learning outcomes. Thus, the researchers developed a way to innovate an instructional material in Chemistry to address the factors that causes difficulties in enriching the science inquiry skills.

Part A. Comparison of variables between the Control and Experimental Groups

Table 5 indicates the significant differences between the profiles of respondents in the experimental and the control groups in terms of their pre-level inquiry skills scores. Since the p-values **(0.77 and 0.75)** of the two groups in Schools A and B are higher than 0.05 level of significance, the researchers failed to reject the null hypothesis. Likewise, general result reveals that the p-value **(0.75)** is also higher than 0.05 level of significance. Thus, it means that there is no significant difference between the profiles of respondents in the experimental and the control groups in terms of pre-level inquiry skills scores as one of the matching variables. Overall, the control and the experimental groups have the same performance level based on first matching variable before the conduct of the study.

Table 5. Significant Difference between the Profile of the Control and Experimental Groups in terms of Pre-level Inquiry Skills Score

School	Group	N	Highest Score	Lowest Score	Mean	SD	Mean Difference	t	*p	Interpretation
A	Control	42	18	3	10.67	3.65	0.53	1.99	0.77	Not
	Experimental	43	18	1	10.14	4.22				Significant
B	Control	26	17	5	11.60	2.98	0.18	2.01	0.75	Not
	Experimental	25	22	7	11.23	3.29				Significant
Overall	**Control**	**68**	**18**	**3**	**10.88**	**3.53**	**0.20**	**1.98**	**0.75**	**Not**
	Experimental	**68**	**22**	**1**	**10.68**	**3.88**				**Significant**

Level of Significance at 0.05

Gay et al. (2012) described the importance of a careful random selection and assignment of respondents at the onset of experimental process. Moreover, Hanita et al., (2017) emphasized confounders such as the pre-assessment scores in an experiment that serve as baseline characteristics must be of similar so that there will be no bias and all observed changes in the teaching-learning process can be attributed to the intervention used. Hence, the researchers selected groups that are of the same level before the onset of the study in determining the effectiveness of the instructional material. Another matching variable strengthened formation of two groups discussed quantitatively in Table 6.

Table 6. Significant Difference between the Profile of the Control and Experimental Groups in terms of Grade 11 General Average

School	Group	N	Highest Score	Lowest Score	Mean	SD	Mean Difference	t	*p	Interpretation
A	Control	42	97	81	90.40	3.05	0.04	1.99	0.93	Not
	Experimental	43	94	81	90.44	3.04				Significant
B	Control	26	96	91	93.96	1.54	0.42	2.01	0.61	Not
	Experimental	25	97	90	93.54	1.76				Significant
Overall	**Control**	**68**	**97**	**81**	**91.60**	**3.11**	**0.14**	**1.98**	**0.81**	**Not**
	Experimental	**68**	**97**	**81**	**91.74**	**3.10**				**Significant**

Level of Significance at 0.05

Table 6 indicates the significant differences between the profiles of respondents in the experimental and the control groups in terms of their Grade 11 general average. Since the p-values **(0.93 and 0.61)** of the two groups in Schools A and B are higher than 0.05 level of significance, the researchers failed to reject the null hypothesis. Likewise, general result reveals that the p-value **(0.75)** is also higher than 0.05 level of significance. Thus, it means that there is no significant difference between the profiles of respondents in the experimental and the control groups in terms of their Grade 11 general average as one of the matching variables. Overall, the control and the experimental groups have the same level of performance based on second matching variable before the conduct of the study.

Gay et al. (2012) described the importance of the careful random selection and assignment of respondents at the onset of the experimental process. However, White and Sabarwal (2014) reminded that the lack of good quality data is a barrier in the matching process. Thus, aside from the results of pre-assessment, Hanita et al. (2017) emphasized another confounder which is the learners' previous academic achievement performance as baseline characteristic before the start of a study to ensure the similarity of the two groups being compared. This posed rejection of bias observed pointing that intervention used has made the necessary improvement. Hence, the researchers had selected groups that are of the same level before the onset of the study in determining the effectiveness of the instructional material. The researchers, to ascertain significant difference between experimental and control groups, followed carefully planned procedures and appropriate statistical measures discussed in the next section.

Table 7 shows the analysis of the data obtained where the p-values **(0.00)** of Schools A and B are lower than

0.05 level of significance. This means that the researchers rejected the null hypothesis. Likewise, the overall results reveal a p-value **(0.00)** which is lower than 0.05 level of significance. The researchers arrived with the same decision. Therefore, there is a significant difference between post-level inquiry skills mean scores of respondents in the control and the experimental groups in schools A and B after the conduct of the study. Hence, the use of interactive courseware integrated in the 7E instructional model is effective in enriching the science inquiry skills of the G12 Science, Technology, Engineering, and Mathematics learners. Furthermore, this indicates that the respondents in the experimental group are able to enrich their science inquiry skills with the use of interactive courseware as supplementary material.

Table 7. Significant Difference between the Control and the Experimental Groups in terms of Post-level Inquiry Skills Score in General Chemistry 1

School	Group	N	Highest Score	Lowest Score	Mean	SD	Mean Difference	t	*p	Interpretation
A	Control	42	32	5	20.07	5.47				
	Experimental	43	40	35	38.77	1.43	18.70	2.01	0.00	Significant
B	Control	26	39	21	26.46	5.73				
	Experimental	25	40	35	38.08	1.29	11.62	2.04	0.00	Significant
Overall	**Control**	**68**	**39**	**5**	**22.51**	**6.24**				
	Experimental	**68**	**40**	**35**	**38.51**	**1.42**	**16.00**	**1.99**	**0.00**	**Significant**

*Level of Significance at 0.05

It can be noted that science inquiry skills of the learners need to be developed for them to concretize their learning. Furthermore, teachers can act as facilitators guiding learners in discovering concepts which they can use in their everyday situations (Adesoji & Idika, 2015). By using the interactive courseware, the learners were able to have a grasp of the essential ideas needed. The 'aha' moments experienced signifies the satisfaction of curiosity of the learners which eventually develops into higher order thinking. Eisenkraft (2003) reiterated the 7E phases. Integration of the concept of *elicit, engage, and explore phases* allows the teacher to find the use of 7E instructional model coupled with interactive courseware helpful in deepening every concept learned in the subject. This also connotes the learning becomes more relevant to them as they apply what has been learned in the activities during the discussion. These encompass *explain* and *elaborate phases* of the 7E instructional model. This connotes that logical sequence of the lesson helps the learners in developing their science inquiry skills.

Moreover, the learners can easily grasp the connection of each phase leading them to construct knowledge and skills as compared to those who are exposed in the conventional method of teaching. This represents the important part of the 7E instructional model which is the *evaluate phase*. Aside from the formative assessment included in the courseware, the teacher has observed that the learners do not stop studying General Chemistry 1 after class. They find it easy to follow the lessons the following day because they have the material which they can browse even without the internet connection. This connotes that learners develop a study habit and can further realize the value of the learned concepts. This complete the 7E instructional model which is the *extend phase*.

Part B. Encapsulating learners' meaningful leaning experiences in the process

This part encapsulates the meaningful learning experiences conceived by the learners during the enrichment process of their science inquiry skills. The use of interactive courseware as 'guide on the side' of learners supplements available learning materials of the teachers in teaching General Chemistry 1 (Stockwell et al., 2015). Prior to the implementation of K to 12 curriculum are the rising problems such as the availability of instructional materials and readiness of the learners to cope up with the challenges of 21st century (Ramirez & Monterola, 2019; Caballero & Cabahug, 2015) that will enhance the inquiry-based learning (Bhagat, 2017; Samaresh, 2017).

The meaningful learning experiences are good indicators of a successful teaching-learning process (Üce & Ceyhan, 2019). Based on this notion, the researchers used careful and thorough documentation of the classroom discussion between the respondents in the control and the experimental groups are taken into consideration. It can be noted that those in the control group are taught using the conventional teaching method while those in the experimental group used interactive courseware installed in their mobile phones integrated in the 7E instructional model.

Science inquiry skills are categorized as basic, the readily observable ones, and integrated, the one that integrates critical thinking and are not readily observable, in science classes (Turiman et al., 2012). This connotes that integrated science inquiry skills are difficult to assess and can only be acquired through time. Additional ideas of Kazeni et al. (2018) explained that these skills can be promoted using the practical investigations leading to the enrichment of the conceptual understanding among learners to carry out activities based on their own hypotheses.

Asking questions about the real world is the first step in developing one's science inquiry skills. A response about this can deemed, to wit:

> *"I like advanced study and we don't have available books provided in Chemistry, so it helps me a lot especially when I'm asking questions about the world. It helps me to improve my inquiry skills during the period I am using it."* (Student 1B, interview).

It indicates that curiosity on what is happening in the surrounding calls for investigation to learn something new. To say:

> *"The application helps me in hypothesizing and exploring as a learner in a way of adapting its content and everything about the lessons contained in this application. Also, I learned how to apply all the lessons that we learned from this interactive courseware."* (Student 4B, interview)

Hypothesizing is giving one's conviction of what might happen beforehand in an experiment. A series of experiments/activities conducted in General Chemistry 1 was embedded in the interactive courseware. The researchers simplified them according to the availability of the materials, time allotment, and capability of the learners to do so. Moreover, the material provides the learners vast source of information which they can

explore thoroughly. After formulating hypothesis, a learner says:

> "*It helps me a lot when I'm tired to review and accomplish homework. Answers can be found in the phone. It is great because I do not need to spend money. Lastly, the courseware helps us in designing and conducting investigations for us to further understand the concepts.*" (Student 8A, interview).

Kazeni et al., (2018) explained that inquiry skills can be promoted using practical investigations leading to the enrichment of conceptual understanding based on learners' crafted hypotheses. Truly, Science encourages the learners to **conduct science investigation** in looking for solutions to problems. This involves easy-to-follow procedures with the tentative answers. The next process is exemplified by the following accounts, to quote:

> "*Due to its concise and clear presentation of the topics it helps us to classify, predict, and describe the concepts at hand.*" (Student 3A, interview)

This is supported with this account:

> "*The application helps me to enrich the science inquiry skills because every topic has specific descriptions that help me in explaining the concepts. I can easily understand the things that the teacher is discussing.*" (Student 2A, interview)

The ability to **classify, predict, describe, distinguish the differences, and explain** the concepts are salient features of science inquiry skills (Labouta et al., 2018). Conversely, Gürses et al., (2015) reported that senior high school students are not yet equipped with these science inquiry skills. It might affect their performance when faced with challenges in college. Thus, the researchers used the learning competencies prescribed in General Chemistry 1 to determine the science inquiry skills needed to be enriched among the learners during the study. These skills are embedded in the topics under the different contents which are the limit of the study. Henceforth, the learners were still able to enrich their inquiry skills. This can be noted as:

> "*We can do advanced reading and in validating our answers in the problem solving.*" (Student 9A, interview). Another learner strengthened the claim by stating: "*The application helps me in communicating results with the use of its content and design because its content has a lot of formulas and problems that really help me a lot in my problem-solving skills.*" (Student 8B, interview)

Last but perhaps not the least of these skills that need to be enriched among the 21st century learners is the ability to **validate and communicate the results**. In every inquiry process involves the authentication of the results. This requires critical thinking and rigorous analysis. After such, the results can then be communicated. All these skills comprise the basic and advanced science process/inquiry skills which are expected to be developed among learners of today. Linking these science inquiry skills to the 21st century can be reflected on these accounts, to wit:

> "*It has problem solving that helped me practice my problem-solving skills. It has definitions that helped us in our homework and school activities.*" (Student 6A, interview)

Imagination has no limits. Hence, learners should be given adequate tasks that will enable them to construct their knowledge and skills. Teaching the learners how to develop their **imaginative skills** enable them to realize

the vastness of information and to consider the world as a learning community with the necessary resources for them to grow. Perhaps one of the most important skills to be developed by the learners to survive in this world is accounted as:

> *"The courseware helps me in enriching my science inquiry skills as it provides a lecture that fit the science subject. Also, it provides some experimental activities that improve my science investigative skills. Also there are different given solutions and formula for solving some scientific mathematical problems that surely help my critical thinking and computational skills."* (Student 3B, interview)

This is added by another experience:

> *"The application really helped me enrich my science inquiry skills. The courseware involves many analytical problems which helped me develop my analytical and hypothesizing skills. I have also enriched my skill in solving mathematical problems in Chemistry with the help of the courseware."* (Student 5B, interview)

Critical thinking and computational skills are two skills needed to be honed among the 21st century learners. Moreover, these skills are vital to certain disciplines like Mathematics, Physics and Chemistry especially when dealing with problem solving. Likewise, learners are expected to develop these skills since they will be dealing with courses which are highly in dire need of them. Belecina and Ocampo Jr. (2018) described critical thinking skill as the use of highly analytical thinking leading to the creation of means to a problem. Hence, these two skills are integrated in the development of the interactive courseware. Lastly, this important skill must be guided properly to be used by learners in developing their own meaning, to quote:

> *"The application helps me in a way that it offers a lot of activities and tasks that strengthen my ICT skills which greatly helps me in understanding deeply all of our lessons."* (Student 8B, interview)

The high demand among teachers, learners, and various educational stakeholders is a challenge that boils down on the manner of ICT integration as part of classroom instruction. This is supported by Mustafa and Fatma (2013) that learners build their own experience by integrating readily available technology learning Chemistry. Moreover, Dewi et al. (2019) supported the idea that ICT-based learning is closely related to essential 21st century skills like collaboration, digital literacy, critical thinking, and problem-solving. Hence, the researchers considered recommendations that learning Chemistry can be better improved using mobile phones, laptop, and desktop as e-learning materials to develop learner's ICT skill.

Phase III. Enhanced 7E instructional model integrated with interactive courseware

Wenning (2011) reiterated that an enhanced model focused on teaching science inquiry skills must be developed based on the intellectual capability and meaningful learning experiences of the learners. Furthermore, it can be noted that approaches used in teaching primary learners are far different to those in the secondary level. The researchers strongly believed that inquiry-based learning is an essential teaching companion to capacitate learner's cognitive and psychomotor prowess by developing the skills necessary to strive in this society.

Likewise, careful consideration must be taken to appreciate its beauty. Needless to say, Chu et al., (2016) described inquiry skill as one of the 21st century salient features needed to be developed by the learners in the current society. Remembering the phases previously described and discussed thoroughly led to the final output of this study. The experiences, themes, and ideas collected out of the responses in the focus group discussions and interviews led to the crafting of the enhanced 7E instructional model (see Figure 2).
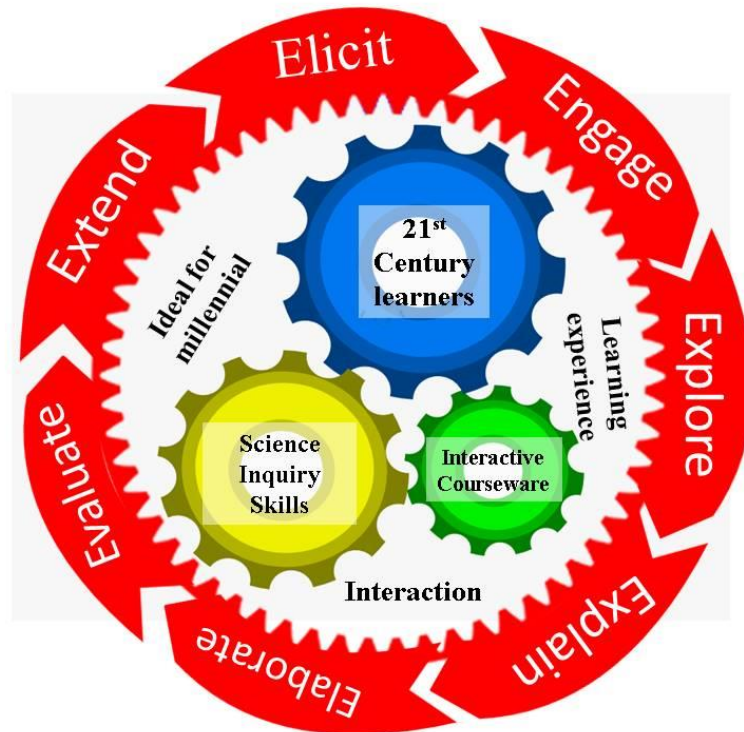
Figure 2. Enhanced 7E Instructional Model integrating the Interactive Courseware

The 7E instructional model developed by Eisenkraft (2003) follows a cycle expanding the previous model crafted by Bybee (1997) which promotes continuity of the learned concepts as one progresses in each phase. Based on the initial framework, the learners typically process information based on logical, chronological, and scaffolded instruction. Hence, the learners generally create meaningful learning experiences from previously held beliefs which, in turn, transformed into newly discovered understanding (Miadi et al., 2018). In cognitive structures, this takes some time before realized. Ideally, present generation has various study habit pattern. Few are still reading their books while most of them are depending on readily available information in their handheld devices/gadgets.

Moreover, they find it convenient and accessible to gather information when they are used to it. As emphasized in the present curriculum, learning experience is strengthened when learners are encouraged to satisfy their intuitive minds by discovering new things. More so, learners tend to collaborate with their peers when they accomplish tasks. Lastly, during the study the learners and teachers develop 'chemical' bonding as they build healthy classroom relationship with the aid of interactive courseware.

Discussion

In Phase I of the study, the researchers determined the causes of difficulties enriching the learners' science inquiry skills. Serving as the baseline data, this gave the study its foundation to further investigate quantitatively and qualitatively. In general, the *nature of topics, learning environment, learner- and teacher-related issues* were found to be the root causes of difficulty in the enrichment of science inquiry skills among Grade 12 learners in General Chemistry 1. Deductively, learners became effective and efficient in learning their lessons when they applied what is learned in their lives (Chu et al., 2016; Kelley & Knowles, 2016). The use of online open sources in teaching arouse their interest and helps learner to organize thoughts (Williams & Pence, 2011). Likewise, they developed their critical thinking as they solved the chemical problems posed in the interactive courseware. Science, as knowledge and process, is learner-centered discipline where learners and teachers are expected to create an environment driven by the people, for the people (Wenning, 2005). Thus, the powers of collaboration and cooperation are developed in the process. Living in a modern society entails that learners should be indulged to become technologically literate citizens capable of extracting the best possible means from the array of possibilities (Nuryana et al., 2020).

Henceforth, based on the responses of the learners, the researchers described that the mind-oriented and values-oriented learners make up the 21st century learning. These two aspects of human as a person are continuously honed throughout their lives seeking along the way yet they lack the ability to transform these ideas into useful ones. These characteristics of the 21st century learners are accompanied by the multitude of factors identified such as *nature of topics, learning environment, learner-related, and teacher-related issues* (Jocz et al., 2014) which are under the second subtheme. This drives the researchers to pursue the study and produce the necessary impact to the educational needs of the 21st century learners. As an offshoot to the identified problems, the researchers developed a way to innovate an instructional material in Chemistry to address factors that causes difficulties in enriching the science inquiry skills.

In Phase II of the study, the encapsulated meaningful learning experiences were conceived from the learners' responses during the enrichment process of their science inquiry skills. Looking back in the previous years of K to 12 curriculum implementation are the rising problems such as the availability of instructional materials and readiness of the learners (Aggabao et al., 2018) to cope up with the challenges of 21st century hindering the enrichment of science inquiry skills. An idea came in to use the widely available mobile phones as a way to cope up with the learners' needs (Laidlaw & O'Mara, 2015; Williams & Pence, 2011). Thus, an interactive courseware in General Chemistry 1 was designed and developed to address the needs as far as inquiry learning is concerned. Integration of the material in the 7E instructional model is not easy. Yet studies have shown that the use of said model as an effective approach in teaching difficult and complex concepts addresses the causes of difficulties in enriching the science inquiry skills (Iksan et al., 2018; Samaresh, 2017; Eisenkraft, 2003). However, the use of ICT integrated in the model has not been given direct emphasis for years. Ultimately, science inquiry skills are enriched when integration of an interactive courseware (Fu & Hwang, 2018) is implemented with 7E instructional model phases simultaneously.

Based on the researchers' careful and thorough documentation of the classroom discussion between the respondents in the control and the experimental groups, it can be noted that the integration of interactive courseware in the 7E instructional model created an impact in the learning style of learners towards Chemistry. This supported by the studies of Samaresh (2017), Balta (2016) and Ruggiero and Mong (2015). Moreover, this signifies an innovation of ideas as to how the learner-centered approach could be carried on using the material. This led to the development of fondness among the learners with regards to unraveling the 'secrets' of Chemistry. Adhering with the constructivist ideas, the interactive courseware welcomed changes happening in the society (Khan & Masood, 2015). Learners were assisted in the process and left to become independent as they construct their own experiences in which they will use in the future (Chu et al., 2016). Likewise, a constructive learner thinks creatively and discovers ways to better understand things (Khalid & Azeem, 2012). Finally, learners connect the ideas they have learned in the past to that at hand in present. This summed up the meaningful learning experiences of the learners with the use of the material integrated in the 7E instructional model.

Inevitably, the factors affecting the science inquiry skills are, by far, the perceived causes of difficulties among the learners and teachers as far as Chemistry is concerned. These, in one way or another, hindered the process of enriching the necessary inquiry learning typically used by learners as science practitioners in years to come. At present, teachers should be vigilant enough to address these issues and create alternative methods along the way. Gone are the days where teachers function as knowledge dispenser while learners are passive receivers of information (Ødegaard et al., 2014). In the current education system, teachers function as facilitator of learning whereas learners are given opportunity to widen their horizon and create deep understanding of the perceived concepts (Faulkner & Latham, 2016; Maeng et al., 2013). In one way or another, this gave the researchers the hope to address the need to continuously improve the inquiry-based learning among the senior high school learners. After all, they are the next generation of professionals who will lead a more progressive and competitive country.

The last phase developed an enhanced 7E instructional model integrating the interactive courseware in General Chemistry 1. The experiences, themes, and ideas collected out of the responses in the focus group discussions and interviews crafted the output the enhanced 7E teaching and learning model. Ultimately speaking, the 7E instructional model is enhanced with the integration of the developed General Chemistry 1 interactive courseware. In turn, the material enriched the science inquiry skills as observed in the learner's responses as well as in their manner of collaboration and participation in the class. The enrichment of these skills created the 21st century learners where they can cope up with the ever-changing needs of the society. As 21st century individuals they are geared to enrichment of their science inquiry skills (Havice et al., 2018; Thibaut et al., 2018). In turn, these skills are geared with the use of interactive courseware.

Conclusions

In general, the *nature of topics, learning environment, learner- and teacher-related issues* were the root causes of difficulty in the enrichment of science inquiry skills among Grade 12 learners in General Chemistry 1. The

implementation of the 7E instructional model was effective in enriching science inquiry skills of the Grade 12 Science, Technology, Engineering, and Mathematics (STEM) learners. The respondents in the experimental group were able to enrich their science inquiry skills with the use of the interactive courseware as supplementary material in General Chemistry 1 as shown in the significant difference between the two group's posttest mean scores. Lastly, the enhanced 7E instructional model was crafted based on quantitative and qualitative data obtained from Phases I and II of the study. Its phases followed cyclic process around the essential elements *interactive courseware, science inquiry skills,* and *21ˢᵗ century learners.* All of these are produced from the recurring codes *ideal for millennial, interaction,* and *learning experiences.*

Recommendations

Implementation of school remediation and enrichment programs can be done to the identified causes of difficulties in Chemistry as well as in other science disciplines. Likewise, an enhanced 7E instructional model integrated with interactive courseware can be utilized by Science teachers and learners in senior high school. Furthermore, the model can be integrated to other science subjects to promote inquiry-based learning towards the construction of learners' meaningful experiences for lifelong learning. This can be tried out in other science disciplines and even in other subject areas to promote the application of inquiry and constructivist approaches in accordance of the K to 12 Basic Education Curriculum. Lastly, school policies can be drafted to support inquiry-based learning creating an atmosphere of collaborative and constructive learning.

Acknowledgements

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