ASSESSING LEARNERS' SCIENTIFIC REASONING SKILLS AND EPISTEMOLOGICAL BELIEFS IN PHYSICAL SCIENCE DURING ONLINE DISTANCE LEARNING

Oris, Ryan S[1*]; Caballes, Dennis G[2]

[1]*Graduate Student, Centro Escolar University, Mendiola, Manila, Philippines*

[2]*Faculty Member, Centro Escolar University, Mendiola, Manila, Philippines*

[*]Correspondence Tel.: +639156652719, *Email: ryansanchezoris@gmail.com

ABSTRACT: *Scientific literacy was viewed as one indicator of quality science education which will greatly contribute to nation-building. However, improving its system is challenging for the Philippine education sector. In addition, public health emergencies were declared, drastically affecting the normal flow of education. Thus, it is imperative to identify the gaps by knowing more about the learners' characteristics during the pandemic. This study assessed the 11th grade STEM learners' scientific reasoning (SR) skills and epistemological beliefs (EB) during online distance learning. Researcher utilized Lawsons' Classroom Test for Scientific Reasoning and Epistemological Beliefs Assessment for Physical Science to ascertain the level, patterns, and correlation of learners' SR skills and EB before and after one semester through pretest and posttest. A descriptive-correlational method was used. It was found out that these learners have low SR skills from both tests. They have low to moderate levels in multidimensional SR. Moreover, learners have moderate levels of epistemology in both tests, and they have moderate to high levels of EB in five dimensions. Lastly, learners' SR skills and EB have correlation between them in pretest but not in posttest. The findings suggest urgent and appropriate interventions to address the need to integrate the variables in curriculum, instructions, and assessments.*

Keywords: *education, epistemological beliefs, pandemic, scientific reasoning skills, senior high school*

1. INTRODUCTION

Nearly all educational institutions across the globe overhauled their educational system during the last two decades to meet the demands of technological advancements. Most of them adopted a twelve-year basic education cycle while other countries had a 13-to-14-year cycle. The Philippines offers the shortest pre-university education cycle. As a result, there is a mismatch between the Philippine and foreign education systems which makes students of Filipino descent academically challenged in global job markets [1]. Last May 15, 2013, the Philippine government passed the enhanced basic education into law. Another two (2) years were added by the government to the 10-year basic education program to strengthen the curriculum. With this, the Filipino leaners will be transformed into individuals who have 21st Century skills and are holistically developed. The government also believed that these skills would make secondary students prepared in higher education, entrepreneurship, and in the field of work [2]. Science, Technology, Engineering and Mathematics or STEM was being offered by the schools as one of the academic tracks in this curriculum. This track encouraged students to choose science-related courses in higher education [3]. STEM Education can produce capable students with 21st-Century abilities who are needed by the nation to advance socially and economically by preparing graduates for better opportunities abroad [4]. The goals of this educational reform are promising. However, it faces several issues and challenges during its introduction and implementation. Furthermore, it was found out that there are flaws in the curriculum as it failed to create an integrative course where all disciplines related to STEM [5]. Additionally, the country's expected learning outcomes of the K to 12 Curriculum Guides were not in line with the established pedagogies [6,7]. Local researchers found overall negative feedback from different stakeholders (parents, students, and teachers) regarding the K to 12 Curriculum [8]. In addition, the curriculum was also impacted by a COVID-19 pandemic that hit the nation which started from the final quarter of the 2019–2020 academic year dated March 15, 2020.

Due to the public health emergency, the traditional classroom-based instruction shifted to alternative delivery modes and flexible learning options. The country's education department implemented alternative learning modality using virtual platforms and modular approach. This is to provide learning opportunities in a safer way [9]. In relation to these problems, it is important to know more about learners especially their characteristics on the current curriculum and during public safety emergency. One way to describe learners' characteristics is by focusing on their cognitive domain such as scientific reasoning skills and epistemological beliefs. Khoirina and Cari [10] cited that in the developmental activity of characteristics of intellectual maturity, scientific reasoning is the end. Thus, it is important to invest while learners are in the secondary level by giving learning activities that are oriented to scientific reasoning. Before finding specific learning strategies and activities, learners' scientific reasoning (SR) skills must first be determined through assessments.

A number of studies have been conducted on teaching pedagogies [11, 12, 13, 14, 15, 16], student preferences and readiness [17, 18], student motivation and attitude [19, 20, 21, 22], teachers skills, competencies, and challenges [23, 24, 25], assessment techniques and tools [26, 27, 28, 29] and other related factors [30, 31, 32, 33, 34, 35] in order to enhance students learning outcome but little was done on investigating students epistemological beliefs and scientific reasoning skills.

With the current curriculum, classroom instructions, and teaching modalities and learning interventions amidst pandemic, it is imperative to assess how students acquire or evaluate knowledge and think scientifically. In Philippines, the K to 12 Program was mandated and implemented dates back eight (8) years despite of professional development efforts and curriculum reforms. In addition, it was found out that the integration of scientific reasoning in instruction is a challenge to junior high school students as manifested by poor scientific reasoning ability. Since pandemic affected the education, how

was the level of learners' scientific reasoning skills during online distance learning modality? Even though there are related local studies about SR, they did not focus on the effects of online distance learning. Aside from that, the learners' patterns of SR skills during this modality remain unknown. *What are the patterns of SR of learners during this modality?* Scientific reasoning catches the attention of researchers since it is part of Next Generation Science Standards [36]. Among the assessments, Lawson's Classroom Test for Scientific Reasoning (LCTSR) became a popular tool in measuring higher order thinking skills of students- scientific reasoning along six skill categories or dimensions. For almost three decades, this task-based assessment has been utilized in probing SR from middle school to university level [37, 38, 39, 40]. Through this assessment, patterns of learner's scientific reasoning skills can be measured by focusing one the performance level of learners on the following SR dimensions: Conservation of Mass and Volume (CMV), Proportional Reasoning (PR), Control of Variables (CoV, Probabilistic Reasoning (PT), Correlational Reasoning (C), and Hypothetical-Deductive Reasoning (HDR). Aside from the skills, the epistemological beliefs (EB), or the nature of their knowledge and how they justify it must also be considered. Due to their potential contribution to learning, several studies determined its positive correlations to academic performance, metacognition, personal beliefs, knowledge construction and acquisition. Few studies focused on its influence on SR skills and vice versa. In describing learners, teachers must not only rely on one dimension of learners' characteristics. These can be described through different dimensions such as personal, cognitive, academic, and social or emotional characteristics. One way to describe learners' cognitive characteristics is by assessing their intellectual skills to identify how they think, solves problems, and how they will learn [41]. In addition, most publications were focused on the construction of instruments in assessing epistemological beliefs and they have suggested similar dimensions that need to be part of the tools. These dimensions are Structure of Scientific Knowledge (SSK), Nature of Knowing and Learning (NKL), Real-Life Applicability (RLA), Evolving Knowledge (EK), and Source of Ability to Learn (SAL) [42]. *During online distance learning, what are the learners' epistemological beliefs in terms of level and patterns?* This question remains unanswered as of writing which may lead to disregarding students' views on the nature of their knowledge and learning during the said modality. Through an assessment, this question can be answered by identifying the level of students' epistemological beliefs in general and their level from its different dimensions. Due to the potential impacts of assessing scientific reasoning skills and epistemological beliefs on education, these areas of concerned have been associated with other areas. For example, SR correlates with metacognitive awareness [43], problem solving abilities [44], academic achievement [45]. In addition, EB was also associated with approaches to learning [46], conceptual change learning [47], motivations, learning approach and achievement [48]. On the other hand, there are also studies that associate SR and EB. Gobert [49] found out that students with sophisticated epistemologies were able to transfer their learning through model-based reasoning. Similarly, Zeinneddin [50] discovered that higher commitments correlate with the quality of reasoning, and it was comparable to prior knowledge. Hotulainen & Telivuo [51] confirmed also that sophisticated poles of EB variables predicted a higher stage of SR. However, the correlation between the two areas considering this alternative modality needs to be identified. Thus, the researcher hypothesized that there is no significant relationship between the learners' SR skills and their EB.

This research study aimed to determine the level and patterns of respondents' SR skills and EB during flexible learning. Specifically, it also aimed to attain the following objectives: (1) to assess the level and patterns of leaners' scientific reasoning skills and (2) epistemological beliefs; (3) to determine the correlation between scientific reasoning skills and epistemological beliefs; (4) to identify learners' characteristics in terms of scientific reasoning skills and epistemological beliefs during online distance learning; and (5) to propose intervention strategies that may be used by the teachers in addressing the gaps among learners' scientific reasoning skills and epistemological beliefs and to improve students' performance. This research aimed to provide an output and results which are deemed significant to the academic stakeholders.

2. MATERIALS AND METHODS

Since the subjects are the learners of the researcher, there is a potential conflict of interest. Thus, they were invited by other teachers to participate with proper communication through informed consent. As part of the recruitment criteria, they must be a regular 11^{th} grade learner taking a STEM track is allowed to participate. There are 241 STEM learners who are qualified and were asked to participate in this research. There are 77 males and 164 females aged ranging from 16 to 19 years old. These projected participants are 11^{th} graders who were enrolled in the school during the first semester of the A.Y. 2021- 2022. However, there are 159 learners who participated in the pretest and 165 learners in posttest. Thus, equal distribution from both tests was not attained due to the absences of learners and no communication despite follow-ups. Thus, the data from pretest and posttest were treated separately by focusing on the learners' overall performance in both tests. To ensure equal variances, Levene's test for equality of variances was performed. They have finished their junior high school or grade level 7th through 10th in the same school, while others finished it from different schools. The participants who just moved up in the school are products of the non-grading system while others are products of the graded system. These backgrounds make the study more relevant because it could determine the SR skills and EB of heterogeneous participants who are products of junior high school. They were from the six heterogenous classes of the STEM track. Since they are under this academic track, they took General Chemistry and Earth Science during the semester which made the study also more relevant as it focused on their EB in Physical Science. Since face-to-face classes were prohibited for primary and secondary level during this period due to the implementation of community quarantine all over the country brought about by COVID- 19 pandemic, the study was conducted virtually using Google Meet for the administration of pretest and posttest. Furthermore, **t**his study is basically a descriptive-correlational research design. Descriptive methods

were used in determining the level and patterns of learners' SR skills, their EB on the aspects of level and dimensions, and to enumerate the identified learners' characteristics. Lastly, correlational study was applied to identify the relationship between the two. In terms of sampling design, purposive sampling was used in the study since it is convenient to the researcher especially during the pandemic in which face-to-face interaction is prohibited and the period of allowed synchronous classes are limited. The data for this research was collected using a questionnaire that has two (2) parts. As mentioned above, the research instrument consists of two parts- the modified LCTSR and EBAPS. After content validation of LCTSR with the help of experts, the questionnaire and EBAPS test items were encoded online through Google Forms. The initial administration of the instrument for pretest was done during the classes' synchronous meetings on the first week of the school year to determine the acquired skill in reasoning as well as their patterns and level after they moved-up from 10^{th} grade. This 12- item and two-tiered instrument was originally designed by Anton E. Lawson [40] to probe students' reasoning skills along six dimensions (conservation of mass and volume, control of variables, probabilistic thinking, proportional reasoning, correlational thinking, and hypothetical- deductive reasoning). The dimensions and their definitions were shown in Table 1.

Table 1. Description of the Six Dimensions of Scientific Reasoning Skills in LCTSR and their Corresponding Statements [52]

Dimensions	Description
Conservation of Mass and Volume	The ability to retain the knowledge even the appearance was changed while specific properties of an object stay the same [53].
Proportional Reasoning	This is the skill of using the equality of two ratios (a/b =c/d) in solving for a term when the other three terms were given [52].
Control of Variables	Changing the variable of interest to determine which variables influence the outcome while controlling all other variables [52].
Probabilistic Thinking	The ability to identify the fraction of the times an event will occur as the possible outcome of some repeatable process when that process is repeated [52]
Correlational	This is the ability to identify the strength of mutual or reciprocal relationships among variables (Adi et al, 2002).
Hypothetical-Deductive Reasoning	This is the skill of making decisions or conclusions from if-then statements [52].

In the second part of the questionnaire, they were asked to read the statements mentally and choose from the options about their level of agreement or disagreement. With this, their initial EB were also ascertained. During the procedure, the equivalent points of the level of agree and disagree in EBAPS were not announced to the learners. After a semester of online distance learning, a posttest was administered to identify the progress of their SR and EB. The same instrument was used for this test. The researcher listed down all the strategies and activities provided by their teachers in Physical Science classes which represents the possible triggers of learners' performance in the assessments. Data will be analyzed through a descriptive method based on the learners' responses on the modified version LCTSR. In addition, one tier- item analysis and two-tier analysis methods were applied.

Assessing learners' scientific reasoning skills

Level of learners' SR. After pretest and posttest, responses were checked with the use of codes- 1 and 0 (1 for the correct answer while 0 for incorrect answer). After coding, the three-level scoring system was applied to identify the score for every item. The three- level scoring system as proposed in [52] gives credit points to students who can give correct answers but incorrect reasoning (1-0) since it indicates a higher level of skill. Two points were awarded to those who got the correct answer and correct reasoning (1-1). There is no score given to the responses which are either incorrect or appear to be guessed characterized by 0- 1 (wrong answer but correct reasoning). The awarded score for all items were added together. The total score of every learner was computed then divided to 24 which is the highest possible score on the first part of questionnaire. The mean scores were then multiplied to 100 to present the scores on a scale of 0 to 100. All the respondents' scores were summed up and divided into the number of samples from pretest to get the overall mean score. These calculations were also applied to identify the overall mean score in posttest. Finally, each overall mean score from both tests were interpreted using SR continuum presented on Table 2.

Table 2. Interpretation of Learners' Responses Using Range of Scores and SR Skills and EB Continuum

Range of Scores	SR Continuum	EB Continuum
0 to 35	Low	Low
36 to 63	Moderate	Moderate
64 to100	High	High

After the interpretation, the results were maximized by computing the percentages of learners who have low-level, moderate, and high SR skills. These percentages were calculated to identify the performance of minority and majority from the tests which backed up the results of two-tiered analysis.

Patterns of learners' SR. The scored items will be used again to identify the patterns of scientific reasoning skills of the learners. As presented on Table 2, the test items were distributed along six dimensions. Since the test items are two-tiered, each item is worth two (2) points. The equivalent points for every dimension considered as the highest possible score that respondents might get in a certain dimension. The computed and interpreted percentage in six (6) dimensions served as the basis of the patterns of their SR skills. In every dimension, the mean score was computed. The mean score in a certain dimension was expressed into percentage by dividing it to the highest possible score of the dimension and multiply the quotient to 100. The SR continuum was also used to interpret the score in percent for every dimension. The percentages of learners of low, moderate, and high level of SR were also computed after identifying their level from different dimensions. The same process was applied to determine the percentages of learners who have moderate and high levels of SR. Furthermore, these findings were summarized to describe the learners' patterns of scientific reasoning.

Assessing learners' epistemological beliefs. To determine the EB of students in the aspect of level and patterns, learners' responses were analyzed descriptively. The level of agreement and disagreement has corresponding points based on the scoring system of EBAPS [54].

Level of learners' EB. After scoring each level of agreement or disagreement from EBAPS statements, the mean scores of all respondents were computed. Since each item has the highest possible score of four (4), the computed mean scores were multiplied to 25 to express the score in a range of 0 to 100 scale. To identify the level of EB of each respondent, EB continuum was also applied. Moreover, the overall level of EB of respondents was based on the overall mean which was then

interpreted either low, moderate, or high EB using the same continuum in Table 2 [54]. Standard deviation was also computed to show the differences and closeness of scores to the mean.

Patterns of Learners' EB. These were ascertained by identifying the level of EB in every dimension. As shown in Table 3, the items of EBAPS were distributed to the five dimensions of EB. Since the responses from every item were already transcribed into their equivalent value, the patterns of EB were dependent on the computed mean on each dimension. After interpretation of mean scores from the five dimensions of EB, the number of learners who have low, moderate, and high levels of epistemology in each dimension were counted and tabulated. These frequencies of learners were then expressed to percentage.

Table 3. Description of the Five Dimensions of EBAPS [56]

Dimensions	Description
Structure of scientific knowledge	This dimension will determine whether students believe in the interrelationship of scientific concepts and principles, or whether these are isolated bits of information that have no hierarchy and structure.
Nature of Knowing and Learning	These are statements or questions designed to measure students' views on how they will understand certain concepts easily. In addition, this dimension evaluates how they will learn using the materials and how they will relate these materials to their prior experience and knowledge. Lastly, it also identifies how students monitor their self- understanding.
Real-Life Applicability	In this domain, the students are asked to reflect on the applicability of scientific ways of thinking in the classroom or laboratory. The students' beliefs regarding the value and application of science in general were also collected in these items.
Evolving Knowledge	This dimension focused on students' views on the nature of scientific theories and concepts whether it is stable or evolving.
Source of Ability to Learn	These EBAPS items are used to probe the efficacy of good strategies and hard work in studying.

Identifying the relationships between SR and EB. Correlational analysis was performed using their percentage scores from LCTSR and EBAPS to determine the correlation between reasoning skills and epistemological beliefs of the STEM students. Then, hypotheses were tested to know which of the hypotheses will be rejected or accepted.

Identifying learners' characteristics in terms of:

Scientific reasoning skills. By focusing on the responses of the majority, the learners' characteristics can be identified. As discussed above, learners' SR skills were explored through two-tier analysis to identify the level and patterns from SR assessments. Furthermore, one-tier analysis was applied also for additional information regarding the population of learners who answered correctly and incorrectly on the multiple-choice part and reasoning part of LCTSR. Since the items are two-tiered, the responses from multiple choice items were tabulated as well as their stated reasons from the second tier. Through frequency and percentage distribution, the percentages of participants who responded correctly and incorrectly from the multiple-choice parts were computed. In contrast, there was also a computation that has been done on the percentage of learners who stated correct and incorrect reasons to support their choice. These processes of analysis were applied to the marked responses from pretest and posttest. The processes of analyzing the data from tier 1 was applied also in analyzing tier 2. In addition, the generalizations from two-tiered analysis of the first part of the questionnaire were used to present learners' characteristics in terms of SR.

Epistemological beliefs. The generalizations from the second part of questionnaire were presented as additional identified characteristics in terms of EB. These were taken from the overall results from the level and patterns assessments of EB.

3. RESULTS AND DISCUSSIONS

Assessing learners' scientific reasoning skills:

Level of Learners' SR. Based on the results from the two tests, learners have low SR skills after they moved up from 10th grade level as shown in Table 4. After one semester, learners' level of SR is still low but there is a little increase on their mean score by 1.31. The result signifies that the current teaching and learning strategies cannot develop SR skills within one semester. Given this condition, SR skills are still considered as a challenge to learners and even teachers on the other second semester. Learners may find difficulties in SR-related activities like experimentations, oral recitations, and essay writing activities in science classes.

Table 4. Overall Results of the Scientific Reasoning of the STEM Learner Respondents

	Mean	SD	Descriptor
Pretest	29.17	14.71	Low SR
Posttest	30.48	12.40	Low SR

In connection to the result presented on Table 4, this was supported by the frequency and percentage of learners who were in low-level, moderate- level, and high- level of SR. Pretest result revealed that 67.92% of them or 108 learners have low-level of SR, 30.82% of the sample or 49 learners have moderate SR, while 1.26% or two learners have high SR skills during pretest. While on posttest, 66.67% or 110 learners have low level of SR skills, 32.73% or 54 of them are moderate, and only one has high level in reasoning scientifically (0.61%). In general, most of them have low-level of SR which back-ups the overall mean from the two-tiered analysis and represents the majority from both tests. The difference on the percentages of learners with low-level of SR after the two tests affect the results on the percentage of learners who have moderate. This has resulted in the increase in percentage of learners who have moderate SR by 1.91%. The percentages from this level after two tests emphasize average level of learners' knowledge on science concepts which is essential to SR. Lastly, the percentage of learners who have high SR during pretest has decreased by 0.65%. This decrease in percentage from pretest to posttest resulted to the increase on the percentage of learners with moderate performance on reasoning. In other words, there are fewer learners who have higher order thinking skills. Moreover, this result suggests necessary enhancements to maintain their level of reasoning.

Patterns of Learners' SR. Another way to describe their SR is through analyzing their performance in every dimension. Based on the pretest results shown in Table 5, the respondents have moderate SR in terms of CMV and C. Moreover, they have low SR in the aspects of PT, CoV, and PR. After posttest, they have moderate SR in three dimensions: CMV, PT, and C while they have low SR along PR, CoV, and HDR. Based on the result, only PT, HDR, and PR show an increase in scientific reasoning.

Table 5: Results of the Patterns of Scientific Reasoning of the STEM Learner Respondents per Dimension (n= 159, 165)

Dimensions	Pretest			Posttest		
	Mean	S.D.	Descriptor	Mean	S.D.	Descriptor
CMV	55.50	31.53	Moderate	51.97	30.12	Moderate
CoV	28.93	23.45	Low	25.35	20.63	Low
C	42.14	45.19	Moderate	37.27	43.71	Moderate
HDR	11.32	19.01	Low	18.03	21.67	Low
PT	35.22	38.18	Low	47.58	39.26	Moderate
PR	8.49	19.45	Low	8.64	20.78	Low
Overall	29.17	14.71	Low	30.48	12.40	Low

With the limited instructional time, traditional ways of teaching were always applied but there's an integration of technology. Moreover, hands-on activities are limited so virtual labs are maximized and giving lectures has been a norm. As a possible result, these conditions and modality contribute to the increase of the three dimensions since theoretical concepts were mostly delivered by the teachers during online class meetings. The table below shows the result from pretest regarding the frequency and percentage of learners who have low, moderate, and high SR skills in every dimension. In addition, the percentage of learners in three levels of SR for all dimensions was computed as shown in Table 6. Most of them have low SR along CoV, HDR, PT, and PR while moderate level in terms of CMV. This result confirmed that these learners have low-level of SR skills based on the overall mean since most of them have a poor performance from pretest in four out of five dimensions.

Table 6. Pretest Results of SR Assessments (n= 159)

SR	Low		Moderate		High	
Dimensions	f	%	f	%	f	%
Conservation of Mass and Volume	32	20.13	77	48.43	50	31.45
Control of Variables	120	75.47	15	9.43	24	15.09
Correlational	79	49.69	26	16.35	54	33.96
Hypothetical-Deductive Reasoning	144	90.57	11	6.92	4	2.52
Probabilistic Thinking	89	55.97	29	18.24	41	25.79
Proportional Reasoning	145	91.19	9	5.66	5	3.14
Scientific Reasoning	108	67.92	49	30.82	2	1.26

Similarly, Table 7 shows that a high percentage of learners who have low SR skills in four dimensions was recorded from posttest while moderate only along CMV dimension.

Table 7. Posttest Results of SR Assessments (n= 159)

SR	Low		Moderate		High	
Dimensions	f	%	f	%	f	%
Conservation of Mass and Volume	42	25.45	76	46.06	47	28.48
Control of Variables	135	81.82	20	12.12	10	6.06
Correlational	89	53.94	29	17.58	47	28.48
Hypothetical-Deductive Reasoning	135	81.82	24	14.55	6	3.64
Probabilistic Thinking	69	41.82	35	21.21	61	36.97
Proportional Reasoning	146	88.48	14	8.48	5	3.03
Scientific Reasoning	110	66.67	54	32.73	1	0.61

Assessing learners' epistemological beliefs:

Level of leaners' EB. The level of learners' EB can be low, moderate, or high depending on the overall score. Before the classes started, learners' EB was at a moderate level which is the same with the result of the posttest. As shown in Table 8, the mean scores in both tests have a difference of 0.14. Furthermore, the level of their EB was considerably the same since both tests resulted in moderate EB.

Table 8. Overall Results of the Epistemological Beliefs of the STEM Learner Respondents (n= 159, 165)

	Mean	SD	Descriptor
Pretest	57.96	16.03	Moderate
Posttest	57.82	7.27	Moderate

Aside from the above result, most of the respondents have moderate EB in both tests. Based on the pretest results, 137 learners or 86.16 in percent have moderate EB while 22 learners (13.84%) possessed higher levels of EB. On the other hand, posttest results emphasize that 82.42% or 136 learners were found to have moderate EB while 17.58% or 29 learners have high EB. In addition, there are differences from pretest and posttest results. In terms of low EB, the percentage of learners decreased by 3.74%. Consequently, there is a 3.74% increase on the percentage of learners who have high EB after the two tests administered. In relation to learning, learners become more knowledgeable as they dived to the course. There are learning gains as results of one semester of online distance learning. In this regard, teachers must reflect on the strategies or techniques that were used during in a virtual classroom or remote learning environment. An improved EB may cause meaningful learning since they will know how to learn and apply it.

Patterns of learners' EB. Based on the result of the two tests administered, the level of learners' EB is different from one dimension to another. Based on the pretest results presented in Table 9, they have moderate EB along SSK and NKL dimensions while they have high EB in terms of RLA, EK, and SAL. After posttest, they have moderate EB in SSK, NKL, and EK while high EB along RLA and SAL dimensions. Additionally, there are no learners who have low EB from both tests. These scores clearly shows that there is no significant improvement in terms of learner's overall performance from EBAPS after one semester of online distance learning. Learners' EB were not affected by the learning modality.

Since the results of the tests can be used as a basis for development programs, it is imperative to determine the number and/or percentage of learners who have low, moderate, or high EB in every dimension of EB.

Table 9. Results of the Epistemological Beliefs of the STEM Learner Respondents per Dimension (n= 159, 165)

Dimensions	Pretest			Posttest		
	Mean	S.D.	Descriptor	Mean	S.D.	Descriptor
SSK	49.16	9.53	Moderate	48.83	9.98	Moderate
NKL	53.60	10.07	Moderate	57.43	13.25	Moderate
RLA	64.31	15.24	High	64.20	18.25	High
EK	67.71	148.97	High	56.62	19.83	Moderate
SAL	72.09	15.51	High	71.15	15.90	High
Overall	57.96	16.03	Moderate	57.82	7.27	Moderate

With the use of pretest results, the percentage of learners in every level of EB were also determined. Most of the learners have moderate and high EB in terms of EK (40.88%) while the

rest of them have low EB in pretest. Along NKL and SSK dimensions, majority of them have moderate EB (76.73% and 84.28%) while high percentage of learners who have high EB in terms of RLA and SSK dimensions (52.20% and 84.28%). On the other hand, the posttest results from EBAPS revealed that most learners have moderate level of EB in EK (46.06%), NKL (75.15%), and SSK (85.45%) dimensions. There are high percentages of learners that have been recorded who have high in the aspects of RLA (50.91%) and SAL (70.91).

Identifying the relationships between SR and EB

To generalize the correlations of SR and EB based on pretest results, Table 10 shows that these two variables have been found to be significantly correlated with their epistemological beliefs with $p<0.05$ but between these relationships, the strength is still negligible. Contrastingly, posttest findings revealed that the two variables were not significantly correlated with $p>0.05$. However, the correlation coefficient between them indicates the strength which is also negligible.

Table 10. Correlation between Scientific Reasoning and Epistemological Beliefs

Variables	Correlation coefficient, r	Sig. value	Interpretation	Decision to Ho
SR*EB (Pretest)	0.197	0.013	Significant	Reject
SR*EB (Posttest)	0.036	0.650	Not Significant	Accept

In overall, the scientific reasoning skills in pretest has significant relationship with EB which partly confirms the work in [51]. It was mentioned in the theoretical framework that higher levels of SR will be attained if EB variables are in high levels. However, the present study found out that the learners' SR is low, and they have a moderate EB. Additionally, one out five variables have no significant relationships with SR which contradicts their findings if EB variables became the basis. Only in SAL as dimension of EB that correlates with SR. Furthermore, it was revealed that only CMV correlated with EB while the five dimensions of SR do not. On the other hand, posttest results revealed and confirmed that the two variables have no significant relationship even the dimensions of SR and EB. With this, the present study became more different from the findings in [49] whereas high-level epistemologies can transfer learning through model-based reasoning. The findings from both tests did not confirm the correlation of SR with learners' metacognitive awareness [[43]. It was found out that SR has no significant relationship with learners' nature of knowledge and learning.

Identifying learners' characteristics in terms of:

scientific reasoning skills. The learners' characteristics before and after the semester were identified based on their SR through one-tier and two-tier analyses. Tier 1 of every question is a multiple-choice type, and the tier 2 is open-ended questions in which they were asked to state their reason. On average, the pretest results revealed that around 35% of them were able to identify the correct explanations or answers and stated accurate and relevant reasons to the two-tier questions. However, 65% of them were unable to identify the correct answers or explanations and stated incorrect reasons. After four months of ODL, there's an increase of around 1% in the percentage of learners on identifying correct answers or explanations. On average, nearly 36% of them identified correct answers or explanations while the rest got incorrect answers. However, there is a significant decrease in the percentage of learners who stated accurate. Consequently, there is a 6% increase in the percentage of students who were unable to reason out accurately. Moreover, their level of SR remains low as revealed by the two-tier analysis. Along with the dimensions of PR, CoV, and HDR, they are still on the low-level of SR. On the other hand, their reasoning skills remained at a moderate level regarding CMV and C.

epistemological beliefs. Regarding EB, they are at a moderate level. Moreover, none of them have low EB. Most of them, or 86.16% of the sample have moderate EB while 13.84% have higher EB. Additionally, they have moderate views regarding SSK and NKL while they have high EB along the dimensions of RLA, EK, and SAL. After the posttest, they still have moderate EB. In comparison to pretest results, none of them were in a low level of epistemology and the majority or 82.42% have moderate EB while only 29 learners or 17.58% have sophisticated EB. After four months of flexible learning, they have high EB in only two dimensions- RLA and SAL. In addition, they have moderate EB on SSK, NKL, and EK.

4. CONCLUSION AND RECOMMENDATIONS:

Here are the conclusions drawn based on the results of the study: In overall, the 11th grade STEM learners have low scientific reasoning and moderate epistemological beliefs before and after one semester of online distance learning in SHS for School Year 2021- 2022. Learners' scientific reasoning skills are multidimensional and are ranged from low to moderate level along six (6) dimensions- Conservation of Mass and Volume, Control of Variables, Correlational, Hypothetical-Deductive Reasoning, Probabilistic Thinking, and Proportional Reasoning. Learners have moderate to high level of epistemological beliefs along the five (5) dimensions- Structure of scientific knowledge, Nature of Knowing and Learning, Real-Life Applicability, Evolving Knowledge, and Source of Ability to Learn. Significant relationships exist in the scientific reasoning skills and epistemological beliefs of newly enrolled STEM learners in grade 11 level. After one semester during the school year, it was found out that these have no significant relationship. Other identified learners' characteristics are the following. Most of the STEM learners cannot identify the correct answer from SR skills test before and after one semester of online distance learning. High percentage of learners can't state reasons scientifically and accurately. Few learners have high scientific reasoning skills. There are no learners who have low epistemological beliefs. Their knowledge was not evolved as reflected in their performance on Evolving Knowledge dimension from pretest to posttest. Here are the forwarded recommendations based on the results and conclusions: (1) Science teachers and administrators are encouraged to consider the findings in preparation for possible shifting of teaching modality, pattern of SR and EB in terms the difficulty of topic as lessons progress in every two (2) weeks. (2) Science educators or future researchers may integrate the different teaching methodologies as another variable for the study. (3) Strengthen their SR and EB, focus on their dimensions especially during planning for possible integration to curriculum. Refer to the recommended actions needed for every dimension in Table 11.

Table 11. Recommendations for Interventions/ Instructional Plan for Every Dimension of the Scientific Reasoning and Epistemological Beliefs

Dimensions		Posttest Result	Recommendations
Scientific Reasoning Skills	CMV	Moderate	Establish concrete scientific knowledge among learners and keep on practicing learners in predicting the possible results through extrapolation approach.
	PR	Low	Provide learning opportunities to think analogically or examine observations to make decisions
	CoV	Low	Expose learners from lab activities by creating or conducting investigations such as controlled scientific experiments
	PT	Moderate	Design and conduct investigations that will draw conclusions from an established procedures or repeated trials;
	C	Moderate	Integrate describing relationships activities in instructions and assessments;
	HDR	Moderate	Provide opportunities for drawing conclusions from if- then statement or hypothesis through lab activities; Ask them to predict possible outcomes in a certain scenario using principles, theories, or hypothetical ideas
Epistemological Beliefs	SSK	Moderate	After presenting science concepts or principles, ask learners to generalize about the prerequisites, and relevance or connections of these to other topics.
	NKL	Moderate	Activate learners' prior knowledge to understand the current or new situations
	RLA	High	Consistent giving real-life problem-solving activities by using data for the solutions through experiments; Integrate real-life connections of the topics in instructions and assessments
	EK	Moderate	Present the timelines of scientific theories; ask students to generalize the journeys of theories and law.
	SAL	High	Keep on providing opportunities for learners to reflect on how they learned the science concepts through peer-tutoring or group activities.

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