International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

Attitude and Cognitive Achievement in VLab Experience of STEM Learners in Chemistry

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Abstract

Laboratory applications are of significant importance in chemistry education due to various limitations and deficiency conditions of the recent traditional laboratory. **Objective:** In order to address the gap, this study examined the effect of virtual laboratory (vLab) on the attitude and cognitive achievement and the relationship of these two variables with one another among 59 STEM students of eleventh-grade (control and experimental group). **Methods:** Study were gathered with pre and posttest using Chemistry Attitude Scale (CAS_1), Cognitive Achievements Scale (CAS_2) test, and augmented with semi-structured interview (ssi) for those who experienced vLab. Comparisons were made within and between groups. Using SPSS software, the mean scores, t-test, and Pearson Product correlation(r) were used to analyze the data, while thematic analysis was used for ssi result. **Conclusion:** It was concluded that both traditional and virtual laboratory elicited positive attitudes and average cognitive achievement among students. Moreover, the virtual laboratory is at least as effective as the traditional laboratory, both in terms of students' attitudes and cognitive achievements. The findings showed also, that there is significant positive relationship in the students' attitude and cognitive achievement in chemistry for both traditional and vLab groups. Furthermore, some students agreed that the vLab can help them to perform the experiments quickly, it invites their interest to move further in the activity, and can perform on their own pace.

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Recommendation: This also suggests that further study is needed in different domains and subscales of attitudes, development of instructional materials which focuses on Bloom's taxonomy should be supplemented for instructions, and enhance quality virtual laboratory to be added to the pedagogy.

Keywords: Virtual Laboratory (vLab); Attitudes; Cognitive Achievement; Chemistry Laboratory; STEM Learners.

1. Introduction

1.1. Background

Chemistry is considered to be challenging subject by the students that attributes negative attitude and difficulty in academic progress [1]. Hence, effective instruction must encourage that promotes positive attitude to yield quality achievement among learners [2]. For the past decades, traditional modes of chemistry education in schools focus on imparting chemistry knowledge to students via instruction, plainly embedded within classroom discourse of scientific discovery [3,4]. Reference [5] accentuated the ineffectiveness of traditional instructional methods that cause lack of understanding in science content and processes when students are subjected to conventional teaching through lecture and demonstration. Thus, laboratory activities are good form of experiential learning where models imply a concrete experience and has a tactile contact with object of study leads to effective learning [6]. However, Reference [7] claimed that learning science has been restrained by the deficiency or inadequacy of laboratory equipment in schools. Moreover, there is challenge in constraints in a real laboratory setting including limited and outdated laboratory equipment, unavailable materials and difficulties in demonstrating techniques due to large class sizes resulting in student crowding [8]. One of the unconventional solutions of these obstacles is the use of vLab. Virtual laboratories have therefore arisen in the institutions as being powerful efficient tools that may offer wide-range alternatives as learning environments that attract students' interest and positive attitudes as compared to traditional instructions [7,9]. In this bound, [10] emphasized also instructions from virtual laboratories significantly increase student achievement levels for it is more detail, compared to the traditional classroom or partially completed experiments. Reference [11] earlier study also realized that virtual lab showed great potential to enhance students' academic achievements if they use appropriate educational approach. Thus, this study aimed to determine the effects of virtual laboratory on the attitude and cognitive achievement of the students towards Chemistry. It sought to compare its effects from traditional laboratory activities to the virtual laboratories with orchestrated interactive applications and simulations. Furthermore, it examined the relationship of attitude and cognitive achievement in learning chemistry in senior high school.

1.2. Problem Statement

1. What is the mean score of the students' attitudes in terms of:

    a. personal confidence toward Chemistry?
    b. usefulness of the subject's content?
    c. perception on teacher's attitudes?

2. What is the mean performance of the students' cognitive achievement in terms of:

   a. remembering level?
   b. understanding level?
   c. applying level?
   d. analyzing level?
   e. evaluating level?
   f. creating level?

3. Is there a significant difference in the students' performance in terms of:

   a. pretest scores on the Attitudes of traditional laboratory and virtual laboratory groups?
   b. pretest scores on the Cognitive Achievement of traditional laboratory and virtual laboratory groups?
   c. pretest scores and posttest scores on the Attitudes of the control group exposed to traditional laboratory?
   d. pretest scores and posttest scores on Cognitive Achievement of the control group exposed to traditional laboratory?
   e. pretest scores and posttest scores on the Attitudes of the experimental group exposed to vLab experiences?
   f. pretest scores and posttest scores on Cognitive Achievement of the control group exposed to vLab?
   g. posttest scores on the Attitudes of the traditional laboratory and virtual laboratory groups?
   h. posttest scores on the Cognitive Achievement of the traditional laboratory and virtual laboratory groups?

4. Is there a significant relationship between the attitudes and cognitive achievement of the students towards chemistry when treated with?

   a. traditional laboratory experience?
   b. virtual laboratory experience?

5. What are the attitudes of the students exposed to virtual laboratory?

2. Literature Review

2.1. Review of Literature

Experimental learning basically is linked on the varied thinking styles of the learners. Reference [12] developed a theory of thinking styles based on two variables: the way learners view the world and the way the students order the world. In the facet of concrete random thinkers, it defines thinkers who enjoy experimentation as divergent thinkers. Students who are eager to take intuitive leaps in order to create essential teaching-learning process, thus the classroom setting requires the thinkers to be allowed to have opportunities to make choices about their learning. Concrete sequential thinkers are thinkers who base their physical world through their senses. They are detail oriented, notice details, structure, frameworks and organization of the learning.

Everything must be practically monitored by the learner's senses himself [12]. These variables support that laboratory work is an indispensable element of understanding chemistry courses [13]. In the chemistry laboratory students become more active in their learning by seeing, observing and doing [1]. Laboratory studies really increase students' interest and abilities for science subjects. [10] expressed that the most efficient way of chemistry education is through laboratories. Laboratory method is one of the learning methods which enables students to prove basic scientific facts in lab environment. Reference [1] also emphasized that there are problems in traditional laboratory applications and make positive contributions in reaching the objectives of an educational system. The use of vlab simulation programs can overcome inadequate laboratory conditions and mistakes occur and even the misuse of the laboratory. Moreover, it can overcome possible dangers also in the real/traditional labs, example a dangerous experiment for human health. Instead of performing dangerous, difficult or impossible experiments, simulations have advantages from the time, security, cost, and motivation point of view of the learners [14,15]. In addition, experimentation time significantly reduces and routine procedures of processing experimental results become less complex. Furthermore, the lack of equipped laboratory apparatus also affects to the difficulty of teachers in teaching science. This was identified in the study conducted by [16]. Insufficient laboratory equipment and supplies is one the contributing factor why teachers encountered difficulty in presenting their lessons in science. Even though it is not the problem of the teachers because this work is already for the school to supply learning materials that are needed still it is not enough reason to accept why they facing difficulties in dealing science subject. Educators today are being encouraged to be creative in presenting their lesson in answer to this lack of laboratory equipment. Hence, teachers' expertise is the best remedy for this kind of problem. By that reason, virtual elements can let students to work independently at their own pace online, learn how to use chemicals and instruments and better pre-plan experiment prior to the instruction proper [17]. Moreover, computer-aided instructional tools have been the trend in the twenty-first century classrooms. The integration of multimedia in the lesson demanded an array of materials that are readily available, purchased or developed by the teacher. Increasing pressures at all levels of education perpetuated a need for time-efficient, effective teaching modalities that maintained the quality of teaching [18]. As a result, the use of computers in the classroom has become inevitable [19]. Furthermore, virtual laboratories provide instruments for education to be done independent from place and time, carries instructions from closed walls of a classroom to anywhere with a computer and enables applications become more dynamic with simulations [20]. The experiments, traditionally conducted in physical labs, can now be performed on a computer. VLs master the difficulty of having mistaken results that occur as a result of poor laboratory conditions or misuse of the tools and equipment in the laboratory [10]. The study performed by [21] elucidated that computer-simulated teaching can enhance learning experience for students and wider educational experience even up to distance students, for it heightens interaction between teacher, students, manager and family. In addition, [22] highly emphasized that vLab can help students conduct experiments and explore phenomena that cannot be conducted in traditional laboratory surroundings. Aside from that, it was confirmed that virtual reality classroom, thus guaranteeing a highly standardized experimental setting that may control special cases like ADHD [23]. Various studies provided evidence that attitude is an important motivator of behavior and positively affects the achievement of students [24]. The attitudes in learning towards a subject can truly affect the interest, concentration, attention and curiosity of the learners to stick further on the topic. [25] realization of the responsibility is directly related to the attitude. Reference [26,27] state that attitude of the

teachers toward science teaching affects not only on the understanding of science but also on the thinking of the teachers. Thus, positive attitudes can help learners to be more productive and can enhance their success and in studying science [28]. Students' academic performance is a fundamental indicator to be considered when defining and planning educational intervention. It includes in the development of curriculum definition and teaching strategy [29]. Due to further explicate the intention of educational system, Benjamin S. Bloom and his colleagues in 1956 was able to publish a Taxonomy of Educational Objectives in the Cognitive domain of the learners. In [30] designed new taxonomical model of learning among 21st century learners. Unlike to the previous Bloom's Taxonomy 1956 which includes (1) Knowledge, (2) Comprehension, (3) Application, (4) Analysis, (5) Synthesis, and (6) Evaluation. Until in 2001 the taxonomy revised into its new framework that encapsulates the following: (1) Remembering, (2) Understanding, (3) Applying, (4) Analyzing, (5) Evaluating and (6) Creating. With regard to attitude intensification, there were various techniques being employed on the pedagogical framework of education. One of these the usage of virtual laboratory or computer-aided laboratory experiments in the course of students' learning. It is observed that VL applications increase students' success. Besides teachers and students who use VL's simulations in the dimensions of planning instruction, learning and teaching through multimedia think that it is helpful [31]. Moreover, it increases students' success and their feeling of competence in lessons. Then, students have developed the positive effects of success on attitudes, motivation of the students and it enables the students to recognize the learnt concepts more easily. Reference [32] found out from the study that the laboratory practices supported with simulations were more effective than the traditional verification laboratory approach in improving the pre-service teachers in chemistry achievement and attitudes toward education technology as well as decreasing the level of their anxieties about the chemistry laboratory. Generally, it was emphasized also by [33,1], that the interactive computer-based experiment improved the students' ability to make acceptable predictions and explanations of the phenomena in the experiments. Besides, vLab experiences and applications made positive effects on students' achievements and attitudes when compared to traditional teaching methods.

3. Research Methodology

3.1. Study Design

Comparative-correlational research design was employed in the study. Moreover, it utilized a mixed-method approach making use of both quantitative and qualitative methods. The quantitative study used the quasi-experimental design [34], pretest and posttest model, and further compare between groups and within group.

There was also a correlation design between attitude and cognitive achievement. Subsequently, the qualitative data was obtained via semi-structured interview to supplement the effect of the intervention.

Control Group	O_1	~x	O_2

Experimental Group	O_3	x	$O_{4/SSI}$

where,

O_1 refers to the pretest scores in Chemistry Attitude Scale (CAS_1) test and Cognitive Achievement Scale (CAS_2) test of the control group

O_2 refers to the posttest scores in Chemistry Attitude Scale (CAS_1) test and Cognitive Achievement Scale (CAS_2) test of the control group

O_3 refers to the pretest scores in Chemistry Attitude Scale (CAS_1) test and Cognitive Achievement Scale (CAS_2) test of the experimental group

$O_{4/SSI}$ refers to the posttest scores in Chemistry Attitude Scale (CAS_1) test and Cognitive Achievement Scale (CAS_2) test of the experimental group and Semi-Structured Interview.

x refers to the use of virtual laboratories in the experimental group

~x refers to the use of the traditional laboratories in the control group

This study was conducted in Polomolok National High School, one of the public educational institutions in Polomolok, South Cotabato. The two selected sections were labeled as group A and group B. The section A was identified as control group and section B was the experimental group, identified through toss coin. They both underwent pretest and posttest on Chemistry Attitude Scale (CAS_1), Cognitive Achievement Scale (CAS_2), and added with semi-structured interview designed for the experimental group only. There were 27 students for the control group and 32 students for the experimental group with 59 students overall.

3.2. Research Instruments

The instruments used in this study were Chemistry Attitude Scale (CAS_1) Test, Cognitive Achievement Scale (CAS_2) Test, and Semi-structured interview. *Chemistry Attitude Scale (CAS_1) Test*, it is an adapted Modified Fennema-Sherman Attitude Scales with a Cronchbach's alpha of 0.91 by [13]. The test includes three (3) subscales: a confidence scale, a usefulness scale, and a teacher perception scale. The confidence scale (C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U) quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' attitudes towards them as learners.

The scores were described and interpreted based on the table below:

Table 1: CAS_1 Test Interpretation

Rating	Scale	Description	Interpretation
5	4.50-5.00	Strongly agree	Highly Positive (HP)
4	3.50-4.49	Agree	Positive (P)
3	2.50-3.49	Uncertain	Moderately Positive (MP)
2	1.50-2.49	Disagree	Negative (N)
1	1.00-1.49	Strongly disagree	Highly Negative (HN)

Negative indicators (scoring was reversed)

Adapted from: Andamon, J. and Tan, D. (2018)

Cognitive Achievement Scale (CAS_2) Test was used as pretest and posttest in order to assess the students' cognitive achievement. The test comprises remembering (R), understanding (U), applying (Ap), analyzing (An), evaluating (E) and creating (C) (Anderson and Krathwohl's Taxonomy of 2001). It is a 60-item test that has 10 items for each level. To test validity and reliability, the researcher sought academic and professional suggestions and recommendations on the questions' construction, suitability of the cognitive skills, and other factors from the experts and teachers who have long experience in teaching Chemistry and curriculum development.

Table 2: CAS_2 Test Interpretation

N	**N**	**Description**	**Interpretation**
10	**60**		
0-2	0-12	Beginning	Very Low
3-4	13-24	Developing	Low
5-6	25-36	Approaching Proficiency	Average
7-8	37-48	Proficient	High
9-10	49-60	Advanced	Very High

Adapted from: Andamon, J. and Tan, D. (2018)

Semi-structured Interviews. This determined the views of the participants on Chemistry vLab activities; it is a supplementary data on the attitude of the students towards the subject. In which, after at least five-week experimental process, there were twelve (12) selected participants from the experimental group [30] to give their both positive and negative views on the application of vLab in the Chemistry class. To maintain the secrecy of the interviewed participant's identities anonymous, they will be coded as S1 to S12.

3.3. Research Methodology

The researchers collected necessary materials prior to the administration of the study such as: (*i*) development and validation by the expert of Chemistry Achievement Scale (CAS_2) test in consonance with [15] Taxonomy of Cognitive Achievement *(ii) prepare the Chemistry Attitude Scale (CAS_1) test adapted from Science Attitude Scale as modified from Fennema-Sherman Attitude Scale, (iii) identify appropriate virtual laboratory anchored to the curriculum (iv) review resources materials and instruments, to ensure the coherence of the competencies with the Department of Education (DepEd) – Minimum Learning Competencies (MLC)*. Subsequently, the researcher asked for an approval to the Division office and School principal of Polomolok National High School and explained to them the purpose and the significance of the study. As soon as the approval was granted, the researcher started conducting the experiment by giving pretest on CAS_1 and CAS_2. When all interventions were taken up for 5 weeks, posttest was administered to both groups. However, the experimental group underwent

semi-structured interview conducted to the 12 randomly selected students.

3.4. Data Analysis

The SPSS statistical analysis program was used to analyze the data. Weighted mean was used to compute the attitude and cognitive achievement levels. While, independent t-test was used to determine the difference between groups, and dependent t-test was utilized to compute the difference within group. Moreover, Pearson Product r correlation was used to answer the relationship between attitude and cognitive achievement. Additionally, semi-structured interview was used to support quantitative data, analyzed through thematic coding.

4. Results and Discussion

Table 3: Mean Scores of the Students' Attitude

	Traditional Laboratory				Virtual Laboratory			
Attitudes Subscales	Pre	Interpret	Post	Interpret	Pre	Interpret	Post	Interpret
C	3.04	MP	3.30	MP	3.23	MP	3.25	MP
U	3.61	P	3.65	P	3.79	P	3.82	P
T	3.80	P	3.78	P	3.77	P	3.85	P
MEAN	3.48	MP	3.58	P	3.60	P	3.64	P

(C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U) quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' According to the obtained values shown in Table 3, there were dynamics in mean scores of all groups to some degree from pretest to posttest. The mean increased for the traditional laboratory (3.48 to 3.58) was 0.10 and the mean increased for the virtual laboratory (3.60 to 3.64) was 0.04. Nevertheless, mean scores of both of the groups were interpreted as positive attitude after the implementation of the treatments. With regard to the three subscales, there were increased for both groups on personal confidence toward chemistry, greater increase on traditional laboratory for 0.26 (3.04 to 3.30) and interpreted as moderately positive. There was only 0.02 increased on virtual laboratory (3.23 to 3.25) and interpreted as moderately positive for both pretest and posttest. Moreover, in the virtual laboratory there were significant increase of the mean values specifically in usefulness of the content (3.79 to 3.82) was 0.03 and perception toward teacher's attitude with an increase of 0.08 (3.77 to 3.85) and all subscales were interpreted as positive attitudes. Consequently, there were decreased on the mean values of -0.02 (3.80 to 3.78) on the perception on teacher's attitude under traditional laboratory but interpreted as positive attitude.

The table 4 presents the cognitive achievement (Revised Bloom's Cognitive taxonomy) reached by the students from control and experimental groups. In traditional laboratory experience the mean increased was 10.00 (19.85 to 29.85) while virtual laboratory got 11.03 (19.72 to 30.75) increased of mean scores after the treatment of

virtual laboratory. Based from the rubric set, it was found out that after the implementation, the students of traditional laboratory and virtual laboratory were interpreted as average in performance.

Table 4: Mean Performance of the Students' Cognitive Achievement

	Traditional Laboratory				Virtual Laboratory			
Cognitive Achievement Levels	Pre	Interpret	Post	Interpret	Pre	Interpret	Post	Interpret
R	3.74	Low	6.63	Average	3.78	Low	6.66	Average
U	3.22	Low	5.41	Average	3.13	Low	6.72	Average
Ap	4.11	Low	5.07	Average	3.66	Low	5.06	Average
An	3.15	Low	4.15	Low	3.56	Low	4.06	Low
E	3.07	Low	3.96	Low	3.25	Low	3.88	Low
C	2.56	Very Low	4.63	Low	2.34	Very Low	4.38	Low
MEAN	19.85	Low	29.85	Average	19.72	Low	30.75	Average

(R) Remembering, (U) Understanding, (Ap) Applying, (An) Analyzing, (E) Evaluating, and (C) Creating

It showed that both traditional and virtual laboratories ranged as "average performance" in remembering, understanding, and applying. While analyzing, evaluating, and creating for both traditional and virtual laboratories were rated as "low performance". Whereas, it can be induced from the data that virtual laboratory capitulated greater mean scores than the traditional laboratory group.

Table 5: Difference of pretest scores on Attitudes of Traditional and Virtual Laboratories

Attitude Subscales	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
C	3.04	3.23	-1.51	0.14	Not significant
U	3.61	3.79	0.90	0.37	Not significant
T	3.80	3.77	-1.68	0.09	Not significant
MEAN	3.48	3.60	-0.86	0.39	Not significant

(C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U) quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' Table 5 shows the significant

differences between experimental and control groups on their attitude's subscales mean scores. The control group got an overall mean of 3.48 while experimental group got 3.60. Using t-test, the t-value is -0.86 and p-value is 0.39. Since p>0.05, then there is no significant difference in the pretest means of the two groups. This implies that both experimental and control groups did not differentiate regarding to the students' attitudes before the implementation of the study.

Table 6: Difference of pretest scores on Cognitive Achievement of Traditional and Virtual Laboratories

Cognitive Achievement Levels	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
R	3.74	3.78	-0.11	0.91	Not significant
U	3.22	3.13	0.31	0.76	Not Significant
Ap	4.11	3.66	1.27	0.21	Not Significant
An	3.15	3.56	-1.42	0.16	Not Significant
E	3.07	3.25	-0.45	0.66	Not Significant
C	2.56	2.34	0.45	0.65	Not Significant
MEAN	19.85	19.72	0.14	0.89	Not Significant

(R) Remembering, (U) Understanding, (Ap) Applying, (An) Analyzing, (E) Evaluating, and (C) Creating

Table 6 proves that the traditional group got an overall mean of 19.85 while, control group got 19.73 mean scores. It revealed that the pre-test scores of traditional and virtual laboratories were not significantly different from each other (t=0.14, p=0.89). Same as true with all the different levels of cognitive achievement for it did not show significant differences in both traditional and virtual laboratories. Thus, there is no bias in the grouping of students in the two groups, and the experiment can be conducted with the condition that the two groups are equivalent on their cognitive achievement levels in chemistry.

Table 7: Difference of pretest scores and posttest scores on Attitudes of Traditional Laboratory Group

Attitude Subscales	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
C	3.04	3.30	-2.10	0.04	Significant
U	3.61	3.65	-0.50	0.62	Not significant
T	3.80	3.78	0.78	0.44	Not significant
MEAN	3.48	3.58	-0.96	0.34	Not significant

(C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U) quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' There were significant changes on different subscales of attitude in traditional laboratory as shown in Table 7. The personal confidence toward chemistry (3.04 to 3.30) confirmed that there was statistically significant difference in pretest and posttest scores (p>0.04, t = -2.10). Additionally, the two subscales proved that there were no significant differences in pre- and

post-test scores of usefulness of the subject (t-value = -0.50, p-value = 0.62) and perception of the teacher's attitude (t-value = 0.78, p-value = 0.44). In general, there was no significant difference in the pretest and post test scores in the control group using traditional laboratory. Hence, it was seen in the traditional laboratory have increased positive attitude of the students (3.48 to 3.58). The increase of positive attitudes is definitely taken from the confidence and increase of learning achievement [38].

Table 8: Difference of pretest scores and posttest scores on Cognitive Achievement of Traditional Laboratory Group

Attitude Subscales	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
R	3.74	6.63	-6.94	0.00	Significant
U	3.22	5.41	-5.60	0.00	Significant
Ap	4.11	5.07	-2.74	0.01	Significant
An	3.15	4.15	-2.95	0.00	Significant
E	3.07	3.96	-2.26	0.03	Significant
C	2.56	4.63	-4.25	0.00	Significant
MEAN	19.85	29.85	-8.73	0.00	Significant

(R) Remembering, (U) Understanding, (Ap) Applying, (An) Analyzing, (E) Evaluating, and (C) Creating

Table 8 shows that there was a significant difference between pretest and posttest scores of each group, favoring the posttest in the traditional laboratory. When overall pretest and postest of the students were examined in detail, there were improvements in mean scores. In remembering increased by 2.89 (3.74 to 6.63), understanding 2.91 (3.22 to 5.41), applying by 0.96 (4.11 to 5.07), analyzing by 1.00 (3.15 to 4.15), evaluating is 0.89 (3.07 to 3.96), and creating by 2.07 (2.56 to 4.63). Overall mean confirmed that there was a significant difference in the results (t-value= -8.73, p-value=0.00). Thus, there were greatest increased in the remembering level, understanding level, and creating level using the traditional laboratory treatment. This is due to detailed lecture and traditional laboratory let the students to be exposed in the "real-life context" of learning. It was seen that the students exposed in spatial skills through tactile experience in the laboratory obtain higher conceptual learning level [39].

Table 9: Difference of pretest scores and posttest scores on Attitudes of Virtual Laboratory Group

Attitude Subscales	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
C	3.23	3.25	-0.06	0.95	Not significant
U	3.79	3.82	-1.44	0.16	Not significant
T	3.77	3.85	-0.35	0.73	Not significant
MEAN	3.60	3.64	-0.70	0.49	Not significant

(C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U)

quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' In the virtual laboratory, table 9 elucidates that in general there were no statistically significant difference on the students' attitudes in favor of the posttest. In the personal confidence of the students have proven by the t-value = -0.06 and p-value = 0.95. Same also with usefulness of the subject with the t-value of -1.44 and p-value of 0.16 and perception of the teacher's attitudes (t-value= -0.70, p-value=0.49). It implies that virtual laboratory did not create a difference on student's attitude. However, it can be noticed that virtual laboratory has improved positive attitude of the students. Very similar result was taken, students attitudes increased positively on both usefulness of the subject and perception on teacher's attitudes. The reason of this low effect size may be the duration of the study [40]. According to [41], the study implemented for 5 weeks may not be sufficient to change the attitudes of students.

Table 10: Difference of pretest scores and posttest scores on Cognitive Achievement of Virtual Laboratory Group

Cognitive Achievement Levels	Traditional Laboratory	Virtual Laboratory	t-value	p-value	Remarks
	Mean	Mean			
R	3.78	6.66	-8.77	0.00	Significant
U	3.13	6.72	-12.99	0.00	Significant
Ap	3.66	5.06	-3.84	0.00	Significant
An	3.56	4.06	-1.64	0.11	Not Significant
E	3.25	3.88	-1.65	0.10	Not Significant
C	2.34	4.38	-5.36	0.00	Significant
MEAN	19.72	30.75	-13.34	0.00	Significant

(R) Remembering, (U) Understanding, (Ap) Applying, (An) Analyzing, (E) Evaluating, and (C) Creating

The pretest and posttest scores of CAS_2 was statistically significant as seen in table 10, favoring in the posttest scores. CAS_2 test revealed that there were increased in the post results after the employment of the treatment. Remembering increased by 2.88 (3.78 to 6.66), understanding increased is 3.59 (3.13 to 6.72), applying is 1.40 (3.66 to 5.06), analyzing by 0.50 (3.56 to 4.06), evaluating by 0.63 (3.25 to 3.88), and creating is 2.04 (2.34 to 4.38). Among the following levels: understanding increased greatly followed by remembering level, creating level, applying, analyzing, and the least in the evaluating level. The use of virtual lab had increased performance significantly in conceptual understanding and science process skills. Thus, the virtual lab can truly flourish mainly the students' mind about the concept's understanding, and application in virtual mode as confirmed by [42]. It was observed that during the application of the vlab, students really appreciate more the simulations and virtual laboratory because they have the first-hand encounter on the learning process. Therefore, understanding among students is really evident.

Table 11: Difference of posttest scores on Attitudes of Traditional and Virtual Laboratories

Attitude Subscales	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
C	3.30	3.25	0.43	0.67	Not significant
U	3.65	3.82	0.19	0.85	Not significant
T	3.78	3.85	-2.90	0.00	Significant
MEAN	3.58	3.64	-0.71	0.48	Not significant

(C) measures the self-confidence to learn and to achieve well on Chemistry tasks. The usefulness scale (U) quantifies beliefs about the usefulness of Chemistry and its relationship to students' education. Then, the Teachers' perception (T) assesses students' perception of their teachers' Table 11 shows the posttest of both control and experimental groups. The overall mean score of the virtual laboratory is slightly greater than the traditional laboratory; there was a difference of 2.34 in favor of virtual laboratory. Although, the difference was not statistically significant, as t-value=0.71, and p-value=0.48. Nevertheless, it is reasonable to conclude that the students have developed positive attitudes toward chemistry. It is observed also, that there were no statistically significant differences on personal confidence toward chemistry, and usefulness of the subject, except on their perception on teachers' attitudes. This indicates that the students showed better positive attitude on their perception with their teacher in virtual laboratory as compared to those who were treated with the traditional laboratory. This attributed to the teachers' time given in the laboratory activity.

Table 12: Difference of posttest scores on Cognitive Achievment of Traditional and Virtual Laboratories

Cognitive Achievement Levels	Traditional Laboratory Mean	Virtual Laboratory Mean	t-value	p-value	Remarks
R	6.63	6.66	-0.07	0.95	Not Significant
U	5.41	6.72	-3.81	0.00	Significant
Ap	5.07	5.06	0.03	0.98	Not Significant
An	4.15	4.06	0.25	0.81	Not Significant
E	3.96	3.88	0.23	0.82	Not Significant
C	4.63	4.38	0.66	0.52	Not Significant
MEAN	29.85	30.75	-0.92	0.36	Not Significant

(R) Remembering, (U) Understanding, (Ap) Applying, (An) Analyzing, (E) Evaluating, and (C) Creating

Cognitive achievement mean scores are shown in table 12. It shows that there was no significant difference of the posttest scores of both traditional laboratory and virtual laboratory (t= -0.92 and p-value=0.36), favoring to the virtual laboratory group. This implies that virtual laboratory is at least as effectively as the traditional chemistry laboratory. Same results were revealed by [43]. Reference [44,10] that there were no significant

differences in learning outcomes between traditional environment and virtual environment. The same study performed also by [45] that there was no meaningful difference between computer simulations experiments and traditional laboratory experiments. Students claimed as well that the use of simulations in a traditional way did not affect their understanding and they saw simulations as games. Thus, simulations perceived by the students as just an interesting tool to play but not an educational supplement for learning. But it contradicts to the results released by [46,47,48] expounded that virtual laboratories significantly increase students' success and their feelings of competence in lessons. Besides students feel more relax, get less tired and understand the lesson more easily. Moreover, this treatment creates very effective learning environment, and supports student-centered education that promise for a great performance [49].

Table 13: Relationship between Cognitive Achievment and Attitudes in Traditional Laboratory Experience

Group Correlated	Mean Score	Computed r_{27}	t stat	p-value	Remarks
Attitude	3.58	0.91	10.79	0.00	Significant Relationship
Cognitive Achievement	29.85				

The result in table 13 shows that r value is 0.91 and t-stat of 10.79, and with lesser p-value (0.00 < 0.05). The null hypothesis is therefore rejected, which means that there was a significant positive relationship between students' attitude and cognitive achievement in the traditional laboratory experience. The study revealed as well that students' positive attitude in chemistry have higher dispositions towards the subject. The finding agreed with of [50] that students' attitude towards science is more likely to influence achievement in science courses. The performance of the students tends to improve further because they have positive attitudes toward the subject. They tend to enjoy more with less apprehensions.

Table 14: Relationship between Cognitive Achievment and Attitudes in Virtual Laboratory Experience

Group Correlated	Mean Score	Computed r_{27}	t stat	p-value	Remarks
Attitude	3.64	0.80	7.19	0.00	Significant Relationship
Cognitive Achievement	30.75				

There was a significant positive correlation between attitude and cognitive achievement using virtual laboratory experience as conformed by the computed-r of 0.80, with a p-value < 0.05 alpha level. Thus, the study revealed that students' positive attitude in chemistry have higher dispositions towards the subject. It was found as well by [51] that there is a positive relationship between students' attitudes towards learning and their academic performance through simulations and computer-supplemented laboratory experience. When learning is able to provide interesting activities for students, and even the participation of students in school decisions have influence on how students feel about learning and how to react to school life [52]. Furthermore, the virtual applications captured the interest, curiosity, and positive attitude as a whole of the learners. This positive attitude is driving them to learn more and enjoy more the teaching-learning process.

Table 15: Positive and Negative Students' Views on Virtual Laboratories

Theme of Attitude	Code	*F*
Positive Attitude towards vLab	Can perform experiments quickly	7
	Interesting to use because conducted in a computer	5
	Everyone can perform the lab on their own pace	3
	Makes the content much easier	4
	Can save from consumables and apparatus	3
Negative Attitude towards vLab	The software is difficult to use	5
	Physical laboratory is very much authentic	3

Can perform experiments quickly

"The materials for vLab are easy to access, since labeled na lahat (ng) apparatus and chemicals" [The materiasl for vLab are easy to access, since all apparatus and chemicals are labeled]. (S3)

The traditional laboratory mostly done for two hours. Meanwhile, in the virtual lab the students can perform the laboratory for roughly one hour only. Since, the vLab does not require any consumables and apparatus to be washed, cleaned and kept. The features of the vlab is giving easy to understand instructions to ease the process of performing the laboratory activities.

Interesting to use because conducted in a computer

During the implementations the students were observed to be very active, and had enjoyed the lesson. Moreover, higher order interactive computer programs with various interesting units are increased students' motivation to learn further [1]. The moving applications and interactive features improved further their interest to explore the virtual laboratory even after their classes. "*Nice kaayo gamiton, makalingaw ang simulations. Unta ingani sa tanang subjects"* [Nice to use, the simulation takes my interest. Hopefully all the subjects will do the same]. (S8) Thus, students become more positive towards using computers for learning. They find simulation of laboratory as motivating and creating a lot of experience [53]. Thus, students' attitude towards learning is evidently manifested because they showed enthusiasm and interest.

Everyone can perform the lab on their own pace

"We could be able to perform the experimentation even after the chemistry class, during our break and even at home." (S3) It is important to present teaching materials according to the learning speed and capacity of each student [53]. The activities supported with technology provide learners with the opportunity to prepare for the activities in their own learning speed. It was observed as well that students performed the virtual laboratory even after the classes, they can do the activities on their own free time.

Makes the content much easier

Science as a subject has always been perceived as difficult and boring because it involves a lot of formulas, analyses, and problems solving [54]. However, it was found out that virtual laboratory can ease the difficulty on the content of the subject. Since the features of the virtual laboratory is easy to explore and friendly to use. Some of the concepts are even discussed and presented in the application.

"Madaling intindihin ang instructions kaysa sa real lab" [Easy to understand the instructions than the real lab (traditional laboratory)]. (S10)

Can save from consumables and apparatus

Materials and deliverables are one of the considerations in the conventional laboratory. Thus, apparatus and consumables sometimes deviate the capacity of the institution to let the students engage in practical activities.

"no more chemicals and materials to bring, much safer and more convenient". (S5) The results also agree with the findings that performing experiments through computer simulations is enjoyable, interesting and free from physical harm [56]. Since the vlab can provide all apparatus and chemicals in the laboratory. It was found out that the laboratory supplies saved much amount of chemicals and consumables in their laboratory practicum. It is much convenient for the school that has scarcity with the supply.

5. Conclusion

The use of virtual laboratory and traditional laboratory in teaching Chemistry 2 for STEM learners helped them to develop positive attitudes in terms of usefulness of the content and their perception on teacher's attitude, while moderately positive on the personal confidence towards chemistry. Moreover, traditional laboratory and vLab improved significantly their cognitive achievement such as remembering, understanding, and applying into average level, while slightly increased on the analyzing, evaluating, and creating levels. Therefore, vLab is considered at least as effective as the traditional laboratory in teaching Chemistry. It can be used as a substitute in performing laboratory activities. Since the application can provide much more apparatus and consumables for laboratory activities. Therefore, students have an access with free, safer, and much interesting laboratory experience on their fingers. Aside from that, it was observed in the course of the study that STEM learners who has positive attitude towards chemistry acquired higher cognitive achievement in the subject. In both treatments (traditional and virtual laboratory experiences), students manifested positive attitude on learning Chemistry and significantly improved even in cognitive achievement. Furthermore, students confirmed various positive implications of vLab in their learning. It helped them to perform quickly in the experiments, increased their interest to learn further the course, and they can perform the laboratory activities on their own pace as provided by the vLab. More students showed also some enthusiasm, optimism, and interests in the whole course of vlab experiences.

Acknowledgements

We gratefully acknowledge Dr. Wildred D. Bidad, graduate school dean, faculty members of Mindanao State University – Graduate Studies for allowing us to conduct this study; our colleagues in the graduate school,

undying support of our friends, family, and to the different institutions who actively participated in this study.

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