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Effect of Chemistry Laboratory Alternative Work (CLAW) on Students Cognitive Skills and Self-efficacy in Chemistry

Anne Tricia A. Marabe, Ma. Chereza M. Magadia, Albert Andry E. Panergayo*

College of Teacher Education, Laguna State Polytechnic University, Brgy. Del Remedio San Pablo City, Laguna 4000, Philippines

*Author to whom correspondence should be addressed;
email: albertandry.panergayo@lspu.edu.ph

ABSTRACT

The educational shift in instructional delivery from conventional settings to flexible learning systems such as online learning and blended learning affected the conduct of laboratory investigation in science classrooms. This study utilized Chemistry Laboratory Alternative Work (CLAW) as a home-based laboratory to provide an alternative learning method for conducting laboratory activities in chemistry. Furthermore, this study investigated the impact of using CLAW in enhancing the students' cognitive skills (*remembering, understanding*, *applying*, and *analyzing*) and Chemistry self-efficacy (*cognitive, psychomotor,* and *everyday application*). The study used a one-group pre-test/post-test design to collect and interpret the data. The participants were 30 senior high school students in a public school in Laguna, Philippines. The expert-validated instruments, the Acid and Base Achievements Test (ABAT) and Chemistry Self-efficacy Scale (CSS), were administered before and after eight sessions of performing the CLAW. Findings revealed that the student's cognitive skills and self-efficacy in chemistry significantly improved based on p-value ($p<0.05$) at a 95% confidence interval. The results support CLAW as an effective tool for fostering students' cognitive skills and self-efficacy in Chemistry. It shows that CLAW provides an active learning environment that fosters multi-sensory experience and self-regulated learning towards enhancing cognitive and self-efficacy skills. This study suggests adapting home-based learning activities to create more learning opportunities for the students in a hybrid learning set-up and to encourage students to engage in independent learning.

Keywords: *chemistry laboratory alternative works; chemistry self-efficacy; cognitive skills; home-based laboratory*

INTRODUCTION

The recent global pandemic shifted the educational system from a conventional to a flexible learning system, allowing students to work both at school and home. This situation presents significant challenges in teaching laboratory courses (Mojica and Upmacis, 2021) in educational institutions that rely heavily on close physical contact with participants to teach laboratory skills effectively (Stenson et al., 2022). Students' inability to conduct face-to-face laboratory work (Stenson et al., 2022) hindered their ability to gain hands-on experience (Mojica and Upmacis, 2021). Fortunately, many strategies for practical work in the sciences supporting online and distance learning have been developed and explored recently (Kennepohl, 2021). Several home-based laboratories (Cash, 2021), home study lab kits, and virtual laboratories (Kennepohl, 2021) have been documented and used as an alternative method of conducting laboratory investigations.

One of the several instructional resources that provide opportunities for the student to perform laboratory activity at home is the Chemistry Laboratory Alternative Work (CLAW) developed by SALTISE (Supporting Active Learning & Technological Innovation in Studies of Education), a learning community from English and French educational institutions that aims to implement evidenced-based pedagogy and instructional innovation. CLAW are ready-made laboratory activities involving various experiments that can be performed at home using everyday household items. CLAW has a very detailed steps and explanations for specific experiments. Every experiment has a course flow that shows an overview of the investigations, objectives, a list of materials required, and easy-to-find alternatives. It also includes follow-up questions about the experiments and a section where students can put pictures while performing the experiments and explain how they intend to do so and describe what happens to their investigation. CLAW also has student experimental data that can be processed to complete the detailed lab report. This differs from a typical experiment because students at CLAW will conduct an experiment at home using household chemicals and materials. CLAW is very simple and helpful, especially for students well-versed in the digital world. CLAW is one method for students to explore their skills and capabilities by conducting experiments independently and being guided by the website. During the COVID-19 outbreak, CLAW was designed to serve as a substitute for in-person laboratories that are typically performed at the collegiate level. It can, however, be used as a lab experiment or for student projects. CLAW is anchored in a Home-based Laboratory (HBL), where students are free to conduct experiments at home and have autonomy in following the procedures provided by the CLAW.

Since HBL gained traction as a practical way of delivering quality science education it refers to a method in which students are given online instructional material and required to complete laboratory exercises in their homes (Santiago et al., 2022). These laboratory exercises use common household materials and mobile applications (Youseff et al., 2021). It is an alternative solution for continuing laboratory activities despite the fact that on-site practical sessions are interrupted or suspended during a pandemic (Velarde et al., 2022). Using HBL, students can do scientific experiments without physically participating in laboratory classes (Youseff et al., 2021). HBL is a convenient method that allows students to develop laboratory skills such as rigor in the procedure, observation, and making conclusions (Velarde et al., 2022). Moreover, it aims to broaden students' knowledge, abilities, and attitudes (Seifan et al., 2020; Gleich et al., 2020).

Integrating home-based hands-on activities into the curriculum of multiple STEM-related subjects increases the students' intrinsic goal orientation and learning strategies (Owolabi, 2021). It is reported in the academic literature that the home-based experimentation helped students learn the course content, recall course material and information, and motivate them to understand the course (Neves et al., 2017). In addition to that, there is a notable pre-to-post changes in participants' motivation in the sub-areas of critical thinking, peer learning/collaboration, and expectancy, as personal learning preferences and responses stayed consistent in the favorable direction from pre- to post-implementation of HBL (Owolabi, 2021).

HBL can improve the learning achievement of students. According to the study by Winget and Persky (2022), mastery learning may lead to enhanced performance, including factors of interest, testing, and feedback. Moreover, experiences in experiments may teach students how to overcome the difficulties involved in closely seeing and interacting with the physical world, such as handling observational tools, comprehending measurement errors, and analyzing and aggregating the collected data. Meanwhile, according to Yeerum et al. (2022), chemistry education curricular adjustments with hands-on laboratories were undeniable in efficiently developing students' technical skills during the university's closure. It deals with students' learning outcomes, including self-efficacy (Ariza, 2022) where perceptions are reinforced by their success in overcoming challenges that naturally arise in daily life. Furthermore, the ability to bounce back from failures aids in boosting perceived self-efficacy. It develops students' practical expertise, enables the recognition of technical advancements and their application in experimental settings, and promotes the growth of scientific thinking (Meng et. al., 2021).

In chemistry education, HBL enables students to conduct an experiment using household chemicals and materials at home (Gunawan et al., 2018), and allows teachers to combine virtual laboratory media with other teaching approaches. In this respect, the effectiveness of different alternatives should be investigated, including remote laboratories, mobile learning platforms, and at-home laboratories (Ariza, 2022). Home experiments work effectively for chemistry-related applications. It is suggested to explore the effectiveness of virtual and home-based laboratories in students' learning outcomes (Lüsse et. al., 2022). It is also imperative that HBL activities provide a low-cost substitute for more conventional techniques that can be used in resource-constrained circumstances (Youssef et al., 2021). Hence, this study is significant for the teachers and students, offering opportunities to explore the methods of teaching and learning considering the context of the students' home through experimentation and practical tasks. This work will also provide baseline data on the effect of HBL on the learning skills and self-efficacy in chemistry. This would help provide less expensive materials in performing experiments. It would also offer a salient contribution to the field of chemistry education through hands-on designed practical experiments employing affordable household items; home-based laboratory exercises provide an adaptive solution that enriches the curriculum for learning (Kibga et al., 2021).

CLAW is a form of an HBL activity centered on chemistry learning in the context of an individual's household. According to Youseff et al. (2021), HBL is an experimental activity in which the instructions are provided online, and the laboratory activity is carried out at home using common household materials and mobile applications. Students can have first-hand experience with the concepts covered in the course in the lab setting at the comfort of their homes. HBL also gives the chance to investigate the techniques and do experiments using materials that are convenient to find. This provides students the experience and freedom to do and manage the experiments independently.

HBL is anchored on David Kolb's (1984) experiential learning theory, which states that learning is acquired by doing. It focuses on the idea that the best way to learn is to have the experience. Similarly, HBL allows students to have hands-on experience through an experiment in their homes. Experiencing hands-on experiments is the most excellent method to learn new things. Moreover, according to Baker et al. (2002), experiential learning theory emphasizes experience because it motivates learning. Knowledge is created through transformative reflection on one's experiences. Students who experience HBL will learn by experience and can apply what they are learning right away to practical situations.

Moreover, HBL is also anchored on self-regulation theory. According to self-regulation theory, individuals can control their actions. Self-regulation is the self-directed process that students use to put their intellectual capacity into task-related skills (Zimmerman, 2001). Similarly, HBL helps students regulate and express their ideas and transform them into learning-related skills. In addition, HBL gives students opportunities to manage their learning. Students must be aware of their cognitive processes and be motivated to take an active role in their education if they self-regulate (Zimmerman, 2001).

Considering HBL is based on experiential learning theory, it holds that cycles of experience and reflection can further develop comprehension and skills. Bloom's taxonomy of learning levels provides the levels of learning, which can be improved in engaging in an experiential learning cycle. Healy et al. (2011) conceptually combine these two theories to show how learning through experiential cycles can systematically bring students toward greater levels of learning.

CLAW was designed as a substitute for in-person laboratories, usually performed at the college level, during the COVID-19 pandemic. This study aimed to investigate the effectiveness of CLAW in enhancing senior high school students' cognitive skills and self-efficacy in Chemistry. It seeks to determine the mean scores of the student's different cognitive levels and mean levels in *cognitive, psychomotor*, and *everyday application.*

METHODS

Research Design. This study used a quasi-experimental design using a one-group pre-test and post-test model. It is appropriate to carry out the analysis because this method compares participant groups and measures the degree of change that occurs due to treatments or interventions. The data obtained is based on the pre-test and post-test assessing the cognitive skills and self-efficacy in learning chemistry before and after using the CLAW.

Participants of the Study. This study used one intact class of 30 senior high school students specializing in STEM track. The students were enrolled in one public secondary high school in Laguna, Philippines, in the second semester (January to July), academic year 2022 to 2023. The age and sex distribution of the respondents were female (43.3%), while the remaining were male (56.7%) students. The majority of the participants are from the age of 18 years old (63.3%), followed by the age of 17 years old (23.3%), and the remainder are 19 years old (13.3%).

Research Instruments. The following instruments were used in this study. The tools underwent expert validation in terms of content validity and reliability tests.

ABAT. Acid and Based Achievement Test is a researcher-developed 40-item test used to assess the students' cognitive skills in Chemistry. The items were adapted from standardized tests such as the California Standardized Test for Chemistry (2009) and the Massachusetts Comprehensive Assessment System for Chemistry. This achievement test was assembled into four sections addressing the cognitive levels of *remembering* (1-10), *understanding* (11-20), *applying* (21-30), and *analyzing* (31-40) skills, where each section is composed of 10 questions. Parallel tests were used in the pre- and post-test.

CSS. The Chemistry Self-Efficacy Scale is adapted from the work of Aydın and Uzuntiryaki, 2009) composed of 21 items. This instrument measured the students' confidence in their ability to perform essential chemistry tasks. The device comprises three parts: self-efficacy for (1) *Cognitive skills* (12 items), e.g., *To what extent can you explain chemical laws and theories?* (2) *Psychomotor skills* (5 items), e.g., *How well can you work with chemicals?* (3) *everyday application* (4 items), e.g., *To what extent can you propose solutions to everyday problems by using chemistry*?

Data Collection. *Pre-experimental.* The researchers asked for permission to utilize the instrument in the study. ABAT and CCSS were validated by experts in terms of content and consistency. The researcher sought approval from the administration in the research site. Upon approval, the endorsements were channeled to key personnel involved, such as head teacher, master teacher, research coordinator, and subject teacher in the research site directly related to the target respondents. The participants were oriented on the nature of the study and were asked about their willingness to participate. The students were introduced to CLAW as integration of home-based experiments for their information and references. The pre-test tools (ABAT, CSS) were administered after the class orientation.

Experimental Phase. The discussion consisted of 8 sessions involving a combination of face-to-face, online synchronous, and online asynchronous sessions. The performance of CLAW follows the sessions stipulated in Table 1. During online synchronous session, virtual meeting platform was used to discuss relevant matters regarding the conduct of the laboratory activity. Students are also encouraged to consult on the challenges encountered during this period. On the other hand, students are given full autonomy of their learning during asynchronous session. The students performed the home-based laboratory activity given a detailed worksheet derived from the CLAW. The students are also directed to CLAW websites and given recorded video to guide them in performing the laboratory activities at home.

Table 1. Learning Activity Session and Learning Modality

Session	Duration	Learning Activity	Type
1	1 hr.	Orientation of the study & Pre-assessment (ABAT & CSS)	Face-to-Face
2	1 hr.	Discussion on characteristics and properties of acids and bases, and properties of water.	Face-to-Face
3	1 hr.	Discussion on the pH and the calculations of the concentrations of hydrogen and hydroxide ions.	Face-to-Face
4	1 hr.	CLAW At-Home Experiment: Volumetric Analysis of Household Acid with Cabbage Juice - Protocol of the Experiment - PDF	Online Asynchronous
5	1 hr.	Consultation Period	Online Synchronous
6	1 hr.	Analysis and Interpretation of Data gathered from CLAW	Online Synchronous
7	1 hr.	Presentation and Summary of Findings	Face-to-Face
8	1 hr.	Post-assessment (ABAT & CSS)	Face-to-Face

Post-Experimental Phase. The ABAT and CSS (Post-test) were administered to the class. The results of pre-test, post-test, and survey were encoded, tallied, and analyzed quantitatively using the test of difference for cognitive skills and self-efficacy.

Data Analysis

The data were treated using IBM SPSS Statistics software version 25 to answer the research problems. Descriptive statistics such as mean and standard deviation with corresponding verbal interpretations were used to describe the cognitive skills and self-efficacy before and after performing CLAW. The *t*-test for dependent sample was administered to determine whether CLAW significantly enhanced the students' cognitive skills and self-efficacy.

RESULTS AND DISCUSSION

This study aimed to determine the effect of using CLAW in teaching and learning Chemistry on students' cognitive skills and self-efficacy in chemistry. Table 2 presents the mean result in every cognitive level on pre- and post-tests.

Table 2. Descriptive Statistics of Pre-test and Post-test Scores of the Students in Different Cognitive Levels

	Pre-test			**Post-test**		
Cognitive Level	**Mean**	**SD**	**Interpretation**	**Mean**	**SD**	**Interpretation**
Remembering	2.00	1.64	Poor	8.27	1.01	Very good
Understanding	4.53	1.61	Fair	7.30	1.78	Good
Applying	2.87	1.22	Poor	7.90	1.37	Good
Analyzing	3.20	1.56	Poor	5.73	1.96	Fair
Cognitive Skills	15.53	3.84	Good	29.20	3.58	Very Good

Key to Interpretation: Very Poor (0.0-1.9); Poor (2.0-3.9); Fair (4.0 – 5.9); Good (6.0-7.9), Very Good (8.0-9.9); Excellent (10);
Cognitive skills interpretation: Poor (0.0-10.9), Good (11.0-20.9), Very Good (21.0-29.9), Excellent (30.0-40.0)

The data revealed the respondents' mean pre- and post-test scores in each cognitive level. In the cognitive level of *remembering*, the data showed that the pre-test of the respondents were all lower than the passing score (*M*=2.00, *SD* =1.64). On the other hand, the majority of respondents' post-test results reach a passing score (*M*=8.27, *SD*=1.01). There was an improvement in the students' *remembering* skills after doing CLAW. The reason for this is that the CLAW provided a question that students must answer utilizing their knowledge from the previous lesson. During the CLAW experiment, the student must measure the indicators, substance, and solvent to correctly compute mole and molarity. Those are the preceding concepts presented before the acid and base discussion.

In the *understanding* level, the data revealed that the students' knowledge on acids and bases was rated as fair (*M*=4.53, *SD*=1.61) before implementing CLAW. After the performance, the students enhanced their knowledge because the mean score (*M*= 7.30, *SD*=1.78) increased. It indicated that the learners developed an ability to understand and differentiate the properties of acids and bases. Additionally, CLAW is a self-explanatory experiment where students are required to understand the instructions to conduct the experiment. This enhances the student's *understanding* while experimenting.

In terms of the *applying* cognitive level, the student performed poorly (*M*=2.87, *SD*=1.22) on the application of concepts on acids, bases, pH, and buffers to real life situations prior to the implementation of CLAW. The students need help performing calculations and relating acid and base concepts on the real-world scenario. After the CLAW experiment, the mean score of the students became good (*M*=7.90, *SD*= 1.37); this is because the CLAW provided the follow-up question that allowed the student to calculate the given problem. In this way, the knowledge of applying a suitable formula for a given problem makes the student test their application skills.

Regarding the *analyzing* cognitive level, the students had poor (*M*= 3.20, *SD*= 1.51) analysis skills before the CLAW implementation. The students' knowledge about analyzing different acids and bases did not reach the passing score. When the CLAW was implemented, this allowed the student to analyze the whole experiment since the instructions required them to understand independently. It enables the student to analyze their steps to accomplish the experiment.

Considering all the knowledge gained during the discussion, the student analyzed the whole experiment activity. This helped the students enhance their analysis skills which helped improve their ability to analyze and pass the post-test score. Most students got a fair score (M= 5.73, SD= 1.96). The comparison of the scores revealed that the students' analytical skills were enhanced after performing the CLAW experiment.

Table 3 shows the descriptive statistics of pre-test and post-test scores of the students in terms of the different dimensions of chemistry self-efficacy skills.

Table 3. Descriptive Statistics of Pre-test and Post-test Rating on Student's Chemistry Self-efficacy

	Pre -Test			**Post-test**		
Dimension	**Mean**	***SD***	**Interpretation**	**Mean**	***SD***	**Interpretation**
Cognitive Skills						
Item 1	4.13	1.31	Fair	6.53	1.22	Good
Item 2	3.97	1.07	Poor	6.70	1.29	Good
Item 3	5.27	1.80	Fair	6.33	1.32	Good
Item 4	5.20	1.86	Fair	6.73	1.48	Good
Item 6	5.30	1.74	Fair	6.93	1.44	Good
Item 7	5.17	1.95	Fair	6.50	1.38	Good
Item 9	4.63	1.43	Fair	6.40	1.10	Good
Item 10	4.67	1.99	Fair	6.33	1.40	Good
Item 14	4.73	1.34	Fair	6.40	1.33	Good
Item 17	4.93	1.48	Fair	6.20	1.37	Good
Item 18	4.63	1.33	Fair	6.17	1.29	Good
Item 19	4.87	1.61	Fair	6.23	1.19	Good
Mean	4.79	1.05	Fair	6.45	1.07	Good
Psychomotor Skills						
Item 5	4.63	1.73	Fair	6.43	1.10	Good
Item 11	4.17	1.58	Fair	6.00	1.17	Good
Item 13	4.57	1.30	Fair	6.30	1.34	Good
Item 15	5.53	2.10	Fair	6.40	1.54	Good
Item 20	5.57	1.87	Fair	6.40	1.30	Good
Mean	4.89	1.34	Fair	6.31	1.09	Good
Everyday Application						
Item 8	4.43	1.01	Fair	6.03	1.16	Good
Item 12	4.20	1.45	Fair	6.10	1.03	Good
Item 16	5.17	1.32	Fair	6.13	1.46	Good
Item 21	5.77	1.61	Fair	6.70	1.37	Good
Mean	4.89	1.10	Fair	6.24	1.09	Good

Key to Interpretation: *Very Poor (0.0-1.9), Poor (2.0-3.9), Fair (4.0 - 5.9), Good (6.0-7.9), Very Good (8.0-9.9), and Excellent (10)*

Before implementing the CLAW experiment, the highest mean value in the *cognitive skills* (*M*=5.30, *SD*= 1.74) was observed on item 6 showing that most of the students have fair knowledge on reading the formula of an element. The lowest mean value (*M*=4.13, *SD*= 1.31) was observed in item 1, indicating that most students showed little understanding and placed lower value in explaining chemistry laws and theories. The highest mean value after CLAW implementation is (*M*= 6.93, *SD*= 1.44) on item 6, and the lowest mean value is (*M*=6.17, *SD*= 1.29) on item 18. It showed that students thought they were good at describing the properties of elements and compounds, writing laboratory reports, and summarizing findings.

In the psychomotor skills, the highest mean value (*M*=5.57, *SD*=1.87) on item 20 and the lowest mean value (*M*=4.17, *SD*=1.58) on item 11 were both interpreted as "fair", suggesting that students have fair beliefs about themselves specifically in carrying out experimental procedures in chemistry laboratories involving laboratory apparatus. After CLAW, the highest mean value (*M*=6.43, *SD*=1.10) observed on item 5 and the lowest mean value (*M*= 6.00, *SD*=1.17) followed on item 11 indicated good ratings. As a result of experimenting with acids, indicators, and solvents, the students' self-confidence in working with chemicals has improved, gaining self-confidence in conducting actual chemical experiments.

In terms of *everyday application*, both the highest mean value (*M*=5.77, *SD*=1.67) on item 21 and the lowest mean value (M=4.20, *SD*=1.45) on item 12 scored "fair" ratings before the implementation of the CLAW suggesting that students have fair beliefs on themselves whether they can apply the chemical theories in everyday lives. This observation includes their views on the extent to which they can recognize chemistry-related courses. After performing the CLAW experiment, both the highest mean value (*M*=6.70, *SD*=1.37) on item 21 and the lowest mean value (*M*=6.03, *SD*=1.16) on item 8 revealed that the students' self-efficacy has improved from being fair to good. The number of students who improved their self-efficacy in using chemical theories to explain everyday life and how well they can recognize chemistry-related courses increased. This implies that the CLAW enhances not just the knowledge of the student but also the beliefs in themselves that they can achieve. If the cognitive knowledge and self-beliefs were compared before and after implementation, it is very evident that knowing enough knowledge reflects on the beliefs of oneself to do the things related to it. It can be proven that implementing CLAW effectively enhances self-efficacy in *cognitive skills* among the learners. Since CLAW is a home-based experiment, similar findings were observed by Zulirfan et al. (2018) that it can encourage, boost, and ensure students' motivation. These types of experiments not only offer students the same learning results as a real-world laboratory but also afford the freedom to complete the task at their own pace that boosts their interest in science and be motivated for the subject. The students' academic self-esteem rose by combining the enhanced autonomy provided by letting them conduct the studies independently with investigation-based learning experiments.

Table 4. Test of Difference between Mean Pre-test and Post-test Scores on Students in Different Cognitive Levels

Cognitive Level	***MD***	***SD***	***t*-value**	***p*-value**	**Interpretation**
Remembering	-3.27	2.21	-8.090	0.00	Significant
Understanding	-2.77	1.98	-7.664	0.00	Significant
Applying	-5.03	1.97	-13.968	0.00	Significant
Analyzing	-2.53	2.08	-6.671	0.00	Significant
Cognitive Skill	-13.67	3.79	-3.79	0.00	Significant

Key to Interpretation: p*<0.05 Significant *p >0.05 Not Significant*

Table 4 shows the mean pre-test and mean post-test scores among the respondents exposed to CLAW experiment. It can be gleaned that there is a significant difference between pre-test and post-test scores among the *cognitive skills* at all levels after the implementation of CLAW experiment. This shows that implementing CLAW statistically enhanced the cognitive abilities of students.

In the first part of the task, it introduced the different indicators present in specific types of chemicals, doing titration, and solving calculations on moles, molarity, and grams of a substance, which it associates with previous discussion before the experiment started. Students should be able to recall the last topic to understand that part. This can be linked to their *remembering* skills. With $p<0.05$, the pre-test and post-test in *remembering* levels were significantly different. This implies that the level of understanding of the respondents based on the *remembering* level has a notable improvement. The *remembering* level was marked to have a significant difference *(MD*=-3.27, *t*=-8.090, *p*<0.05), implying that the students' *remembering* skills improved before and after the experiment's performance. The same claim (Steffens et al., 2015) from previous study stating that performed actions just like a subject-performed tasks appear to be remembered particularly well, and better than observed actions or experimenter-performed tasks. Enactment appears to improve recognition memory.

Table 4 also displays the significant difference (*MD*=2.77, *t*=-7.664, *p*<0.05*)* between the mean pre-test and mean post-test scores of the respondent at the *understanding* level. This indicates that the *understanding* of the student improved after doing the CLAW experiment. This result was achieved because CLAW is a self-explanatory task for the student. The CLAW provides a step-by-step procedure on what to do and the materials needed. The student needs to comprehend the instructions to conduct the task fully.

Additionally, understanding the topic of acids and bases is a big help for students to answer the follow-up question. Since CLAW provides a multi-sensory learning experience, it enhances the students' understanding of the topic under study. If the students actively manipulate materials, observe changes, and are physically engaged in the experiment, they form a stronger association with the concept being learned, leading to enhanced *understanding*.

The significant difference of pre-test and post-test scores at the *applying* level (*MD*=-5.03 and *t*=-13.968, *p*<0.05) is also shown in Table 4. There is a substantial difference between the performance of the student in the pre-test and post-test after performing CLAW suggesting that students can apply more concepts in a real-world scenario and apply knowledge on calculation. Among the cognitive levels linked to CLAW, application is one evident part that can be enhanced for the student. CLAW allows students to do problem solving, applying their knowledge on the calculation of concentration, pH, and titration, in particular to the latter part of the experiment. It is also evident that CLAW is a hands-on activity where students can readily apply what they learned from the theoretical discussion. It enables them to use their knowledge in practical investigations and transfer knowledge into real-life settings, enhancing their ability to apply knowledge.

In terms of the *analyzing* level, a significant improvement (*MD*=-2.53, *t*=-6.671, *p*<0.05) was also observed, indicating that students can analyze more concepts about acids and bases after the experiment. Likewise, CLAW enhances the *analyzing* skills of the student by providing avenues to collect, organize, and analyze data at their own pace and time. Through the conduct of CLAW experiments, the students engaged in analyzing and interpreting the experimental results, fostering their analytical thinking skills and cultivating their capacity to examine and make sense of the scientific information.

The students' *cognitive skills* were significantly enhanced after performing the CLAW. The ability of the student to apply the formula in the calculation process, to calculate different equations in pH, and to apply the concept of acids, bases, pH, and buffers into real life scenarios was improved. Based on the given goals of experiential learning, participants in exercises to explore the use of experiential learning can make the individual apply the body knowledge on the methodology of academic discipline and develop self-knowledge and skills. Thus, all the levels of cognitive skills revealed that it has a significant mean difference, and all the p-values are all less than 0.05, leading to the rejection of the null hypothesis.

Table 5. Test of Difference between Mean Pre-test and Post-test Rating on Chemistry Self-efficacy

Cognitive Level	***MD***	***SD***	***t*-value**	***p*-value**	**Interpretation**
Cognitive Skills	-1.66	1.39	-6.56	0.00	Significant
Psychomotor Skills	-1.41	1.71	-4.53	0.00	Significant
everyday application	-1.35	1.57	-4.72	0.00	Significant
Mean	-1.63	1.52	-5.88	0.00	Significant

*Key to Interpretation: *p<0.05 Significant *p >0.05 Not Significant*

Table 5 presents a significant mean difference (MD=-1.66, t=-6.56, p<0.05), indicating that the student's self-beliefs about their *cognitive skills* improved after the CLAW experiment. The CLAW enriches the knowledge it gives the student's confidence to apply that knowledge in the context of chemistry. The same findings revealed the students' actual *cognitive skills* from the previous table. The parallel result can be attributed to the nature of CLAW being a hands-on activity that provides students with a sense of responsibility and ownership on their own learning. They independently control their learning process by conducting experiments at their homes. This allows the students to experience success and failure eventually building their confidence and belief about their ability to excel in chemistry cognitive tasks.

Table 5 also shows the statistical difference (MD=-1.41, t=-4.53, p<0.05) between the mean pre-test and post-test ratings on the cognitive dimension of chemistry self-efficacy. This implies that the student's self-belief in *psychomotor skills* improved after performing the CLAW task. Since the experiment involved handling acids and bases, the belief in working with chemicals increased since they experienced it in the CLAW. Although the investigation is home-based, they can still apply their knowledge on how to measure using syringe, and how to refine the vitamin C and ascorbic acid tablet with the available home apparatus. Aside from that, the realization of students themselves to carry out experimental procedures in chemistry experiments was achieved since they had the experience to handle the experiment on their own.

Table 5 also revealed significant improvement (MD=-1.35 and the t=- 4.72, p<0.05) in students' self-efficacy in *everyday application*. The result indicates that the ability of the student to apply the concept of acids and bases before and after the experiment improved. The students' beliefs in proposing solutions to everyday problems by using chemistry, especially on the pH level, improved significantly. Through performing CLAW, students develop a sense of competence in bridging chemistry concepts to practical investigation and real-life scenarios.

The self-efficacy of the student towards chemistry generally improved after the CLAW experiment. Their beliefs on themselves changed because of the activities they performed. Since the CLAW is a home-based experiment, the students only rely on themselves while experimenting. According to Botella et. al. (2018), students develop their perceptions of both their learning skills and their capacity for creativity when they actively engage in these tasks and experience proficiency.

CONCLUSIONS

This study aims to investigate the impact of performing CLAW on the student's cognitive skills and self-efficacy in Chemistry. Results showed that there was a significant improvement in the student's cognitive skills and self-efficacy in all dimensions after performing CLAW. CLAW, as a home-based laboratory activity, provides an active learning environment by which students actively engage in hands-on experiments and practical exercises. Through performing CLAW, students gained opportunities to apply theoretical knowledge in real-life settings, fostering retention of concepts, more profound understanding, and higher confidence in the subject matter. Furthermore, CLAW prompted the students to establish autonomy and self-direction in their learning. They take responsibility for their learning by organizing, performing, and managing the materials and procedures involved in the activity. This promotes self-direction and self-regulated learning enhancing their chemistry task self-efficacy. Hence, CLAW emerged as an appropriate and effective tool for enhancing students' cognitive skills and self-efficacy in chemistry. CLAW further presents an excellent potential for assisting academic institutions in avoiding learning gaps caused by extended distance learning.

The alternation of learning modalities due to unavoidable circumstances such as a pandemic uncovered the vulnerabilities in our current educational system. This prompted educators to devise innovative solutions to address the learning gaps and continue to deliver quality education. Given this, the following are recommended: CLAW can be adapted and integrated into teaching and learning Chemistry to offer practical methods of conducting laboratory investigations, especially in flexible learning settings and unforeseen events such as prolonged lockdowns in the future. Since CLAW uses the fact that home can also be a learning avenue, teachers must be creative in developing learning scenarios in the context and comfort of the students' home, considering the individual differences. It is recommended that future researchers conduct a parallel study assessing two groups to compare the cognitive skills and self-efficacy of the students to other interventions. Likewise, a qualitative inquiry can also be done to substantiate the quantitative findings in this study. Future research may also highlight other outcome variables aside from cognitive skills and self-efficacy to further provide evidence of CLAW's effectiveness of CLAW in enhancing chemistry learning outcomes.

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