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Project HANDLE: Home-Based Activities Needed for Distance Learning Experiments and their Effect on the Development of Science Process Skills of Grade 7 Learners

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Abstract

This mixed-design study was implemented through a one-group pretest-posttest pre-experimental design in a secondary school at Cagraray Island, Philippines using the printed Project HANDLE manual. Project HANDLE is a stand-alone intervention composed of home-based laboratory experiments that target the development of science process skills (SPS) of 35 Grade 7 learners in Life Science delivered through distance learning modality. This study aims to assess the effectiveness of Project HANDLE in improving the SPS of Grade 7 learners as a springboard for the construction of a framework for home-based laboratory exercises. A validated researcher-made test and a survey questionnaire were used to collect data on scores of the pretest and posttest, and experiences in the implementation of Project HANDLE. To rank the tested SPS, descriptive statistics such as mean, percentage, and mean gains were employed, while inferential statistics such as t-test and Cohen's d were used to assess the significance of the differences in scores and the degree of influence of the intervention. Results revealed significant improvement in the level of each tested SPS ($p<0.05$) with Measuring as the most developed SPS and Observing on the opposite extremity. The code of experiences of the learners in Project HANDLE showed five factors, (1) overcoming anxiety, (2) independence, (3) enjoyment, (4) conceptual formation, and (5) ease. A framework for distance learning modality on laboratory experiments was proposed, integrating contextualization, culture-based approach, and brain-based approach to assure the development of SPS and other laboratory factors. Project HANDLE was found to be effective in developing SPS, while it is recommended to use the intervention for integrated SPS and implement the proposed framework. Furthermore, the outcome implies that SPS can be developed without the supervision of a teacher or an expert.

Keywords: *Distance learning, Experiments, Home-based learning, Laboratory work, Science process skills*

1. Introduction

The Covid-19 pandemic has suspended the functioning of several establishments, including schools, to prevent the virus from spreading further. Schools recommended new normal systems to preserve the need for learning even while the risk of infection continues to

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rise. The provision of distance learning modality, which allows schools to adapt to the best-suited method of learning delivery, has mirrored the most viable solution to sustain learning for schooling in the Philippines. While some schools use radio-based instruction, television-based instruction, and online or digital learning, the majority of underprivileged schools favor the modular approach [1].

Science instruction revolves around three learning domains: (1) idea mastery, (2) scientific attitude acquisition, and (3) science process skills development [2]. For many years, the strategy for achieving the three science domains was scaffolded by a more knowledgeable individual in the classroom, who was often represented by a science teacher. Because reference tools and concepts were merged in the construction of learning resources, whether on radio, television, online/digital, or modules, idea mastery and scientific attitude were undoubtedly established even with the emergence of distance learning modalities. However, Science Process Skills (SPS) necessitate the requirement to conduct laboratory experiments under the supervision of a teacher-expert. As a result, teachers are unable to promote and encourage learners to conduct laboratory experiments at home. This is in addition to the issue of not being able to provide learners with distance learning kits with glassware and chemical consumables. Is this to say that SPS development lags in science learning domains during distance learning modalities? If this is the case, what innovative approach may be proposed to augment learning resources without jeopardizing learners' safety when conducting home-based experiments? In light of these identified gaps, this study aims to assess the effectiveness of innovative home-based activities for mobilizing laboratory experiments at home in the development of learners' SPS.

1.2. Literature review

SPS is vital for learning science as it provides the platform for higher skills like reflective thinking and discovery knowledge. This develops the scientific character of a learner to lead him to test his ideas, as most scientists do in conducting scientific methods to test an inquiry. Rezba et al. [3] cited six of the most basic SPS, which include (1) observation, (2) communication, (3) measurement, (4) classification, (5) inference, and (6) prediction. Being an individual’s armor for life [4], SPS is a set of skills that develop when learners are immersed in activities such as scientific investigations, experiments, and fieldwork [5] that challenge their ability to perform scientific inquiry. Furthermore, Roberts [6] cited that SPS is one of the scientific literacy dimensions and must be part of the curriculum reforms as a core objective of science education [7].

One of the ways to best develop SPS is through the use of laboratory experiments in classrooms with specific opportunities for these skills to develop [8]. According to Baillie and Hazel [9], laboratory experiments should act as a "cookbook" with features encouraging independence and growth, enhancing learning, the integrity of the practical classes, and facilitating and coordinating. Science instruction without laboratory experiments are like impractical science with one sense organ removed [8]. Due to the perceived danger when learners are entrusted to do experiments alone without teacher supervision, the conduct of laboratory activities was toned down or omitted in the delivery of distance learning resources at home during the pandemic era. This scenario influences the restrictions of experimental application in disciplines such as science [10], yet regular involvement in practical tasks allows for the development of self-regulation abilities, motivation, communication, cooperation, and holistic skills [11].

During the pandemic, studies by Galusha [12] and Dalgarno et al. [13] found that distance learning impaired motivation and SPS, particularly when laboratory tasks were merely offered in the form of assignments. This is consistent with the reports of Sparks [14], who noted that the majority of teachers and learners struggled in science teaching and learning as the online platform was not considered "conducive to learning" and it is hard to engage learners in collaboration and discussions online. In response to the distance learning mode, an article published by The Conversation [15] focused on some of the laboratory approaches that learners in remote learning might apply. One of the options proposed is the utilization of home lab activities that make use of the materials available at home. In a study conducted by Rusmini et al. [10], they employed self-project-based learning to find genuine projects and create contextual products connected to learners' daily lives [16]. Their work demonstrated the efficiency of individualized project-based learning in improving SPS, particularly in Chemistry.

Findings by Usman et al. [17] demonstrated that the virtual laboratory ensured the development of SPS in the same way or even better than the traditional laboratory, while Aththibby et al. [18] provided a restrained approach for SPS development by using a mobile laboratory-based learning model in developing SPS and motivation. A lot of research on addressing SPS through distance learning emphasizes the use of technology, incorporating a laboratory approach, yet not all schools have the privilege of having access to modern technological breakthroughs and advancements.

Consultation of the reviewed studies and documents in the literature body showed that SPS development is aided by the integration of laboratory experiences of the learners in science instruction. Though the majority of the interventions provided for SPS development in distance learning modalities were primarily focused on the use of technology, no accounts in the literature demonstrated the use of a material in-print to address SPS development through mobilized learning, particularly for less privileged schools which do not have access to technology.

1.3. Development of project HANDLE

In the context of the school locale, Grade 7 learners showed poor SPS based on the consolidated results of summative assessments of distance learning packets. Although teachers' assessment results focus on scientific knowledge, the average percentage of some items that subtly assess SPS was revealed, like that of predicting (31%), classifying (22%), observing (34%), and inferring (8%), as indicated by teachers' item analyses. Following the results, the percentage distribution provided a descriptive equivalent of SPS ranging from little or no proficiency to partial mastery of the specified process skills.

To address the school's low level of SPS in distance learning, this study proposed Project HANDLE (Home-based Activities Needed for Distance Learning Experiments), a stand-alone manual for laboratory experiments with five laboratory activity sheets for Grade 7 learners primarily intended for use in schools without access to technology. The development of Project HANDLE was assisted by the Most Essential Learning Competencies (MELCS) [19] for Grade 7 life science, as well as the prescribed guidelines by LRMDS [20].

Project HANDLE includes learning experiment episodes that allow each target SPS to develop. This intervention enables learners to do experiments remotely while building their SPS and preventing potential health risks. The design of Project HANDLE is based on the notions that experiential learning helps in skill development [21], and that connectionism should be established from initial knowledge representation to become highly skilled [22].

Schema is required for skill acquisition [23]. This attests to the evidence that the use of known materials and prior knowledge of the learner are prerequisites for SPS to cultivate. Using the assessment form provided by LRMDS for PRINT resources [20], a panel of science master teachers evaluated Project HANDLE, and they found it to be very satisfactory in all four areas. The intervention did, however, need to have a few lines changed to level off the target learners' capabilities.

The intervention was tested for two months to ensure that the desired SPS was fully acquired. Project HANDLE recognizes the potential of providing quality education by building SPS in the context of the new normal. This SPS promotes the development of scientific inquiry abilities, which are necessary for 21st-century learning. Project HANDLE's laboratory activities, its entry point in Grade 7 science MELCS, and the target SPS developed are highlighted in Table 1.

1.4. Theoretical underpinnings of project HANDLE

The idea of constructivism supported the current study by putting a premium on "mental construction" as a medium for instruction. The build-up of learning is achieved based on the context of how the information is taught as well as on the beliefs and attitudes of the learners. Learners accommodate new information by following what they already know through knowledge accumulation and experience [24]. Constructivism revolves around two key ideas: tabula rasa is not real and learning is active [25]. The acquisition of new knowledge is supervised by field experience and linked to the learners' prior knowledge. Operationally, this theory suggests that skill and learning acquisition are supervised by what the learners already know. Therefore, the use of contextual or home-based materials as a medium for laboratory experiments will trigger the acquisition of SPS through laboratory experiences.

Table 1. List of innovated laboratory activities in project HANDLE with its corresponding MELCS and target SPS

Innovated Project HANDLE	Entry points in MELCS for Grade 7 life science (code)	Target SPS	Duration
Lab 1. Constructing water-droplet microscope: A prototype light microscope	Identify the parts of the microscope and their functions (S7LT-IIa-1)	Measuring Inferring Observing Predicting	1 week
Lab 2. Observing animal and plant cells using a water-droplet microscope *Paramecium* from hay infusion Onion cells	Focus specimens using the compound microscope (-) Differentiate plant and animal cells according to the presence or absence of certain organelles (S7LT-IIc-3) Explain why the cell is considered the basic structural and functional unit of all organisms (S7LT-IIe-5)	Observing Communicating Classifying Predicting Inferring	3 weeks
Lab 3. Classifying the mode of plant reproduction	Differentiate asexual from sexual reproduction in terms of (1) the number of individuals involved, (2) similarity to parents (S7LT-IIg-7)	Classifying Observing Communicating Inferring	1 week
Lab 4. Symbiotic Relationships	Describe the different ecological relationships found in ecosystems (S7LT-IIh-10)	Observing Classifying Communicating Inferring Predicting	1 week
Lab 5. Biotic and abiotic factors	Differentiate biotic from abiotic components of the ecosystem (S7LT-IIh-9)	Observing Measuring	2 weeks

in the ecosystem	Predict the effect of changes in abiotic factors on the ecosystem (S7LT-IIj-12)	Communicating Inferring Predicting	

With the introduction of distant learning as the new normal, laboratory supplies (both consumables and equipment) cannot be sent as part of the learning kit, and learning activities must be scaled back to accommodate the availability of materials at home in the learning packages. Others might restrict learners' exposure to mobile laboratory experiments due to perceived risk in the absence of expert supervision.

The ongoing scenarios caused by the pandemic to the structuring of laboratory experiences should be a critical vantage point for developing a contextualized laboratory manual that caters to scientific investigations and simulation-based laboratory experiments utilizing home-based materials to boost the development of SPS remotely. The construction of this context-based laboratory manual is cutting-edge in terms of bridging the gap between remote learning and scientific investigations/simulation-based laboratory experiences as possibilities to enhance the SPS of Grade 7 learners. This was consistent with data compiled of poor SPS (from little or no proficiency to partial mastery of the ability) from summative assessment results of Grade 7 learners during the distant learning modality. [Figure 1] demonstrates the union of the theory and its operational use in the study.

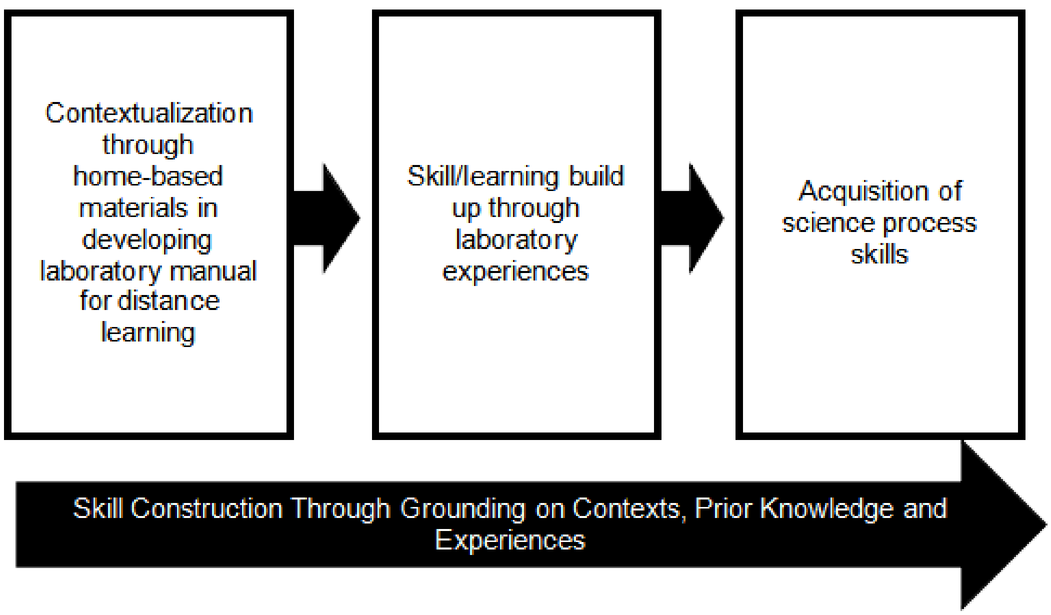

Figure 1. Operational use of constructivism in the development of science process skills through contextualization

In this study, the innovated home-based laboratory manual for distance learning experiments was tested for its effectiveness in developing basic SPS as indicated for Grade 7 by Evangelista [26] along with (1) observing, (2) communicating, (3) measuring, (4) classifying, (5) inferring, and (6) predicting. The laboratory manual intervention, derived from the Most Essential Learning Competencies (MELCS) of Grade 7 life science, made use of readily available materials at home without jeopardizing the health and safety of learners during the mobilization of innovative laboratory experiences.

1.5. Objectives of the study

In line with the accounts in the reviewed literature body and theory for skill development, this research aims to assess the effectiveness of Project HANDLE in improving the SPS of Grade 7 learners as a springboard for the construction of a framework for home-based laboratory exercises. This study was carried out in a public secondary school in Cagraray Island, Bacacay, Albay, Philippines that utilizes a modular approach for distance learning. Specifically, this research attempts to answer the following action research objectives:

1. Identify the level of Grade 7 learners' SPS before and after the implementation of Project HANDLE;
2. Determine the significance of the difference in the level of SPS before and after the implementation of Project HANDLE;
3. Describe the effectiveness of Project HANDLE in developing the SPS of Grade 7 learners;
4. Account for the learners' experiences in the conduct of Project HANDLE; and
5. Propose a framework for SPS development gleaned from the findings of the study.

2. Research Methodology

The study is mixed-methods of quantitative and qualitative approaches. The one-group pretest-posttest pre-experimental design was the overall structure of intervention testing using Grade 7 learners from the 3rd section of a secondary school in Cagraray Island, Philippines. The intervention focused on six SPS: (1) observing, (2) communicating, (3) measuring, (4) classifying, (5) inferring, and (6) predicting.

Two validated research instruments were used to measure the development of SPS as to (1) a 12-item researcher-made test based on the six SPS identified, with open-ended laboratory scenarios. Three points were allotted for each open-ended scenario, yielding a total point score of 36. This instrument was used for the pretest and posttest of SPS development. The data were analyzed using descriptive (mean, percentage, mean gains) and inferential (t-test, Cohen's d) statistics to rank the SPS levels, the significance of the difference between the pretest and posttest, and the magnitude of the intervention's effect. (2) A reflection questionnaire appended to the researcher-made test was also given after the implementation of Project HANDLE to take into account the learners' experiences in the mobilization of laboratory experiments. To derive categorical factors for laboratory experiences using the intervention, narrative data were analyzed using a content analysis technique.

2.1. Respondents of the study and sources of data

The foundation of Project HANDLE was the MELCS for Grade 7 life science. As a result, the intervention's target respondents were Grade 7 learners. Thirty-five (35) registered learners from Section 3 were employed to engage in the Project HANDLE implementation for SY 2022-2023. The section was chosen based on its learners, who all use the module, and the randomization of its enrolled learners, who best represent other minority sections of the Grade 7 level.

Two data sources were used in the implementation of the study; (1) scores from the pretest and posttest of Grade 7 learners from the researcher-made test; and (2) narratives of experiences to document learning in Project HANDLE from a survey questionnaire.

(2) Scores from the researcher-made pretest and posttest were utilized to determine the level of SPS before and after Project HANDLE intervention. Likewise, these data sources were also used to determine whether significant changes in SPS development occurred. Scores were also considered to determine the degree of effect of Project HANDLE in the acquisition of SPS. Before data collection, the validation of the researcher-made test used for this data source included the use of item analysis and KR21 through pilot testing. The results show that the instrument is good for classroom assessment with minimal alterations needed to be made to 3 identified hard items.

(2) Written experiences from a survey questionnaire were used to determine the experiences of Grade 7 learners in the implementation of Project HANDLE. This source of data probed their attitude and acceptance of laboratory experiments mobilized at home. These were collected after the Project HANDLE implementation. Before collecting the data, questionnaire validation for this data source was done by establishing face validity. The instrument was evaluated by experts for its ability to capture the essence of the topic. Pilot testing was also carried out on a subset population of 50 participants, whose responses were analyzed using Principal Component Analysis (PCA) and Cronbach Alpha. Revisions were made to some items with questionable internal consistency.

2.2. Data gathering methods

Following the approval of the research proposal and letter of endorsement from the school head of the target school, the curriculum chairperson of Grade 7, the adviser of Section 3, and permission from the learners' parents, the research data collection strategies were carried out as follows:

The researcher-made test on SPS was delivered first as part of the distance learning packet for 35 Grade 7 learners. The retrieval of the answered test was made simultaneous to the retrieval of learning packets;

Project HANDLE was mobilized for two months. Constant monitoring of the learners was mediated by the class adviser. While waiting for the full accomplishment of Project HANDLE, the researcher started checking the pretest and tabulating the results. When the implementation of Project HANDLE was over, the same researcher-made test for SPS was delivered to Grade 7 learners as a posttest. In addition, the validated survey questionnaire was also delivered.

The retrieval of the answered posttest and survey questionnaire was made possible simultaneously with the retrieval of the learning packets. Posttest scores were tabulated along with pretest scores and processed through descriptive and inferential statistics.

Data analysis of the consolidated numerical and narrative data was conducted to deduce the information from the learners; and

The researcher drafted the initial findings of the paper and used them to generate the final discussion of the paper.

2.3. Data analysis plan

For research objective 1, scores from the 12-item researcher-made test were treated using descriptive statistics through means, mean gains, and percentages on the level of SPS before and after the implementation of Project HANDLE. Triangulation of these statistics was considered to rank the tested SPS. The scale from Boho [27] was used to calculate the level of SPS from the percentage of scores. Table 2 displays the range of score percentages for the level of SPS descriptive equivalence.

Table 2. The descriptive equivalent of SPS level from the percentage range of scores in the pretest and posttest

Percentage Range	Level of SPS Descriptive Equivalent
76%-100%	Advanced
51%-75%	Meets the desired skill
26%-50%	Partial mastery of the skill
0%-25%	Little or no mastery of the skill

For research objective 2, inferential statistics examined the significance of the difference between the pretest and posttest SPS scores. The t-test was especially used to gauge the significance of the score difference. This statistical method determined if the intervention had a substantial impact on SPS's learning acquisition;

For research objective 3, inferential statistics using Cohen's d expanded by Sawilowsky [28] was used to quantify the degree of influence of the intervention in the development of SPS, which examined the effectiveness of Project HANDLE in creating SPS. This was used to determine the degree of the effect of the intervention while eliminating extraneous variances that pose a threat to the data credibility. Table 3 shows the standard for calculating the effect;

Table 3. The descriptive equivalent of the degree of effect of intervention from Cohen's d value (as expanded by Sawilowsky [28])

d value	Effect size
1.21-2.0	Huge effect
0.81-1.20	Very large effect
0.51-0.80	Large effect
0.21-0.50	Medium effect
0.11-0.20	Small effect
0.0-0.10	Very small effect

For research objective 4, on experiences in Project HANDLE of Grade 7 learners, content analysis using codes of the consolidated experiences from the reflection questionnaire was used to support the quantitative findings of the study. This was used to consolidate the possible categories of the codes in generating the laboratory factors based on experience; and

For research objective 5, on the proposal of an educational framework for SPS development, implication analysis was performed to deduce the findings of the study utilized and adapted for educational use. This analysis technique was adapted to state the implications of the results to come up with an educational framework. This proposed framework will help teachers and educational reformers develop educational strategies to develop SPS in the distance learning modality.

3. Results and Discussions

The following narratives were the salient findings of the study, themed by established research questions.

3.1. Level of science process skills before and after the implementation of project HANDLE

After the implementation of Project HANDLE, scores on the researcher-made test were tabulated for the pretest and posttest. Table 4 summarizes the results of testing via descriptive statistics to compare the score results.

Table 4. Comparative results of pretest and posttest scores using the researcher-made test measuring the acquisition of individual SPS through project HANDLE

SPS	Test	M Score*	Gain	*sd*	Perc.	Descriptive Equivalent**
Observing	Pretest	2.63	1.66	1.21	43.83	PM
	Posttest	4.29		0.95	71.50	MDS
Communicating	Pretest	2.40	2.06	1.14	40.00	PM
	Posttest	4.46		1.07	74.33	MDS
Measuring	Pretest	2.49	2.28	1.09	41.50	PM
	Posttest	4.77		1.03	79.50	A
Classifying	Pretest	2.40	2.09	1.01	40.00	PM
	Posttest	4.49		0.98	74.83	MDS
Inferring	Pretest	2.80	1.71	1.18	46.67	PM
	Posttest	4.51		0.99	75.17	MDS
Predicting	Pretest	2.71	1.75	1.18	45.17	PM
	Posttest	4.46		1.15	74.33	MDS

**Maximum point score for every SPS in the pretest and posttest is 6.*
***Legend: PM (Partial mastery of the skill); MDS (Meets the desired skill); A (Advanced)*

Based on the cast of the mean score and its corresponding descriptive equivalent in the pretest among all SPS measured, it showed that Grade 7 learners have already established partial mastery of the skill. This was revealed in the mean score range from 2.40 to 2.80 with Communicating and Classifying, and Inferring on the mean score extremities. Nevertheless, the level of SPS measured during the pretest was described as partially mastered by the learners, which could be attributed to other extraneous factors like test structure, previous experiences, and cognitive condition during the examination. On the other hand, the results of the posttest indicated higher mean scores uniform across all SPS. This was illustrated as supported by the cast of posttest mean scores ranging from 4.29 to 4.77, with Observing and Measuring on the mean score extremities. Among the six tested SPS, only Measuring revealed a posttest equivalent of Advanced (A) with the highest mean gain, while the rest were described as Meets the Desired Skill (MDS). On the contrary, Observing, which is an elementary skill among the basic skills tested, is revealed to be the most difficult aspect developed as supported by the least mean gain, although an increase in the posttest mean score is observed.

Meanwhile, the observed leap in the mean posttest scores is evidenced by the mean gains to the pretest mean scores. This observed improvement in the scores of the learners is a representation of the positive effect of Project HANDLE in developing the SPS of the learners and can be used as a good learning material augmentation to develop the acquisition of SPS. In the Science curriculum framework [29], it was noted that science learning should focus on three domains, which include: (1) understanding and applying scientific knowledge in a local setting; (2) performing scientific processes and skills; and (3) the development of a scientific attitude. This suggests that learning science should not solely focus on the attainment of knowledge but rather a repertoire of holistic learning development, including skills and attitude. Hence, the use of Project HANDLE assists the development of SPS, which is a skill by nature, as evidenced by the leap in the mean scores from the pretest to the posttest. Furthermore, this attests to the fact that the provision of a home-based laboratory manual immerses the learners in learning episodes that allow them to develop other facets of science learning domains, particularly in SPS.

One characteristic of Project HANDLE was its indigenization of the materials used for the home-based laboratory. Hence, the material runs synchronous to the idea of contextualization, where learners would assimilate knowledge and skills when the new material is related to their cognitive architecture [30]. Underlying scientific and psychological features of the developed laboratory manual aided in the gain of SPS since the intervention is of relevance to the learners' means of living. Literature has a handful of accounts testifying to the effectiveness of context-based instruction and its allies, like culture-based approach and indigenization, in the development of conceptual understanding [31][32][33] as well as SPS attainment [34][35][36]. Science learning should not simply revolve around knowledge construction but must also target the recalibration of actions and behaviors, indirectly connoting the importance of SPS development [37].

Accounts in the literature show that Measuring is the most developed SPS. The research conducted in Indonesia entailed research findings exhibiting very similar results to the present research. Utami et al. [38] found that Measuring was the most developed SPS among seven basic skills tested for first-year college learners in Biology class. Moreover, the one-shot case study conducted by Dewi et al. [39] showed parallel results to the present research findings on the standing of Observation skills. In their study, they found out that Observing is one of the least developed SPS next to Communicating using practicum activities of a context-based module. The development of the skill to observe was described as "good" along with other SPS measures.

The data showed that Observing is the least developed SPS. Knowing that Observing is the foundation of most SPS [40], it was predicted that the development of other SPS would be hindered or minimized. Notwithstanding this anticipation based on common sense, it is quite intriguing as to how other process skills were optimally developed, like Measuring, which is a skill offshoot of Observing [40]. This development of other SPS despite the lagging behind of observation could be attributed to other unnoticed skills serving as mediators in the development of other SPS or a typical error in the instrument usage and methodological design. Nevertheless, this mismatch in the literature body vis-a-vis the present findings should be thoroughly investigated.

The current research signified the utmost improvement in Measuring while a development delay was recorded in Observing. However, an opposite finding was documented in the study of Bataller [41], who inversely discovered that Measuring is one of the least developed basic SPS while Observing is one of the most developed basic SPS. Variation in results might be attributed to differences in data-gathering methods and the use of research instrumentation with biases on opportunities to develop each SPS. These findings could be associated with the nature of Measuring with expected output expressed in the dimensions of numerical estimations or calculations leading to exact numerical results, thus the answers are objective. Furthermore, observation is much more holistic, yielding abstract results that can be expressed numerically as well as narratively. Given the subjective nature of observation skills, this could be a barrier to its maximum development unless observation limits were carefully established in experimentation or assessment.

Following the ranking of mean gains, it was demonstrated that Inferring was one of the least developed skills next to Observing. This was backed up by the study of Rezba et al. [3] generating the same findings, labeling Inferring as one of the most difficult SPS to be developed. Moreso, Akani [42] generated similar findings exhibiting the poor development of the skill to infer in a study conducted on 200 senior high school learners in science. Figure 2 shows the degree of improvement for every SPS from the pretest to the posttest, denoting Measuring with the greatest leap of improvement based on the mean score while Observing with the least gain.

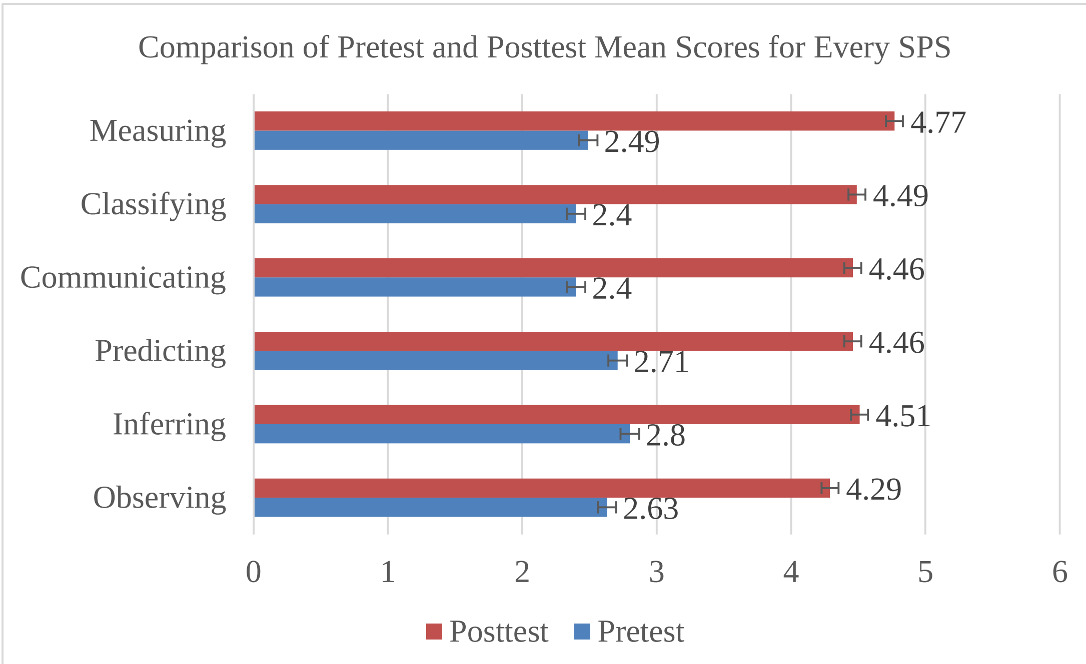

Figure 2. Leap in Mean Scores from pretest to posttest for every SPS measured

Despite the hardship of developing other SPS, Bibon [43] noted that repetition of a series of laboratory experiments would soon develop the skill as long as opportunities for each SPS being measured are available and attainable. The overall assessment of SPS revealed an increase in all SPS tested, disregarding the mean gains. A springboard of Partial Mastery of the Skill (PMS) was reinforced to a majority of Meets the Desired Skill (MDS) equivalent with Measuring as the only skill that met the Advanced (A) category.

3.2. Significance of difference in the level of science process skills before and after the implementation of project HANDLE

The rationale for the use of comparative analysis is to determine if the implied improvement in each SPS is significant or not. Table 5 showed that all tested SPS significantly improved regardless of the mean gain following the casting of pretest and posttest mean scores in [Table 4]. This statistical analysis result indicates that Project HANDLE was effective in developing the set of skills tested and that the intervention is a good alternative to direct instruction in the advent of distance learning as a mode of skill development. Although Measuring and Observing skills were at the extremes of the mean gain, their improvements were found to be evident in the original cast of pretest scores. Limitations were still laid down in the conduct of the comparative testing. Though its purpose is to determine the significance of the difference in the mean scores between the pretest and posttest for each SPS, the result cannot depict which SPS has significantly improved by using another SPS as a point of reference. Hence, vertical comparative testing of pretest and posttest mean scores for each SPS was an established limit.

Table 5. Significance of difference between pretest and posttest results for every SPS

SPS	Assessment	M Score	*p*-value (p=0.05)*	Significance
Observing	Pretest	2.63	5.21E-07	Significant
	Posttest	4.29		
Communicating	Pretest	2.40	5.17E-09	Significant
	Posttest	4.46		
Measuring	Pretest	2.49	2.55E-07	Significant
	Posttest	4.77		
Classifying	Pretest	2.40	1.1E-07	Significant
	Posttest	4.49		
Inferring	Pretest	2.80	3.14E-10	Significant
	Posttest	4.51		
Predicting	Pretest	2.71	5.42E-10	Significant
	Posttest	4.46		

**Significant at two- and one-tail.*

In an unpublished study by Baroso [44], he indicated the development of integrated process skills in chemistry using the same approach of mobilizing laboratory learning materials by virtue of contexts. Pretest and post-test scores were found to significantly differ, while "Making a Conclusion" (MC) is the least developed skill. Similarly, the published study of Gastar and Linaugo [45] revealed a significant improvement in the development of SPS via a modular approach, although they failed to present the individual development of each SPS measured. A significant improvement in the level of integrated SPS was also recorded in the study of Dela Cruz [46], who developed experimental science modules for middle school learners. This documented work and the present study hold sufficient ground in the effect of contextualizing laboratory experiences at home, or self-managed learning, as supported by parallel results obtained from previous research findings and the present approach used as an intervention to develop SPS. Furthermore, it is important to note that self-managed learning does not only develop basic process skills, but it also has a linear effect on the development of integrated SPS. The accounts of the present work testify to the possibility of skill development even without the direct supervision of an expert. This could mean that learners manifested independent learning based on the structure of the learning material provided. Therefore, a quality-assured learning material grounded on the nature of the learners is an antecedent to igniting motivation and drive for learning a skill. These features of Project HANDLE are essential to instilling independent learning at home.

Adding the results of the present study to the literature-based findings, it showed that there is a harmonious relationship of evidence suggesting the effectiveness of home-based laboratory experiments in developing SPS via distance learning modality. This result could be an indication of the power of contextualization, as characterized by the home-based laboratory manual when applied not only to acquire knowledge but skill development as well.

3.3. Effectiveness of project HANDLE in developing science process skills of the learners

Given that multiple extraneous variances, such as the learners' prior knowledge and the structure of the test, could potentially affect the experimental testing, it is appropriate to use effect size to describe the overall influence of the intervention on SPS acquisition while excluding the impact of these external factors. The results of effect size statistics are presented in [Table 6].

Table 6. The effect size of the project HANDLE in the development of SPS using Cohen's d expanded by Sawilowsky (2009) coefficient

SPS	d value	Effect Size
Observing	0.98	Very large effect
Communicating	0.85	Very large effect
Measuring	1.09	Very large effect
Classifying	1.00	Very large effect
Inferring	0.89	Very large effect
Predicting	1.06	Very large effect

Project HANDLE had a very large effect on the development of each SPS. Although the effect size is similar to all tested SPS, the d value seemed to have a significant large effect in Measuring followed by Predicting. This could mean that the structure of Project HANDLE has provided numerous opportunities for these skills to be developed at their optimal level. However, the cast of mean scores previously showed that Predicting is one of the skills that is least developed, although a significant difference in pretest and posttest mean scores are deduced. This is an indication that opportunities to hone the ability to predict are provided in the material, but minimal progress in its development is observed. This is an attestation that Predicting skills are difficult because they require consolidation of all facts and observing the patterns of data behavior [47]. Furthermore, predicting skills are frequently confused with hypothesis and theory, even though they are entirely different variables [47]. Mauldin [48] stated that "prediction is different from a hypothesis or a theory because it addresses the particular experimental design at hand. The prediction describes what the data should look like if the hypothesis or theory fits the real world. True enough, predicting skills are hard to attain, but developing their maximum potential can be addressed by providing multiple-shot experiments with opportunities for the skill to develop [43].

A very large effect size would imply that there was little impact from extraneous variances and that the majority of SPS acquisition was a result of the developed home-based laboratory experiment. Similarly, another study that tested the development of SPS using an inquiry-based module found a moderate effect in the development of SPS using the intervention [49]. In a 2011 study by El-Sabagh [50], he also tested the effect size of a virtual lab in each of the six basic SPS. The study found that the intervention had the weakest/smallest effect in the Measuring skill while Inferring and Communicating were almost at the top of the rankings, which are all contradictory based on the findings of effect sizes in the present study for each SPS. The literature provided an array of opposite results and unrelated findings regarding the effect sizes of interventions in SPS development. Whichever is the reflection of the truth, this shows that the interventions used might cause varying effect sizes in the acquisition of SPS. A thorough investigation needs to be conducted to analyze the effects of different interventions on SPS mastery.

3.4. Learners' experiences in the conduct of project HANDLE

The pandemic has altered the mode of instruction in schools by ensuring the continuous delivery of instruction without compromising the health of learners. While there are other modes for learning using technology-assisted instruction, the majority of the schools implemented a modular approach as deemed relevant based on the capacity, appropriateness, and capability of schools and their catchment areas. Recent studies, particularly the ones by

Barcenas and Bibon [1], found that academic burnout was experienced by learners due to modules bombarded with multiple activities, not to mention the hectic deadlines, while learners juggle responsibilities both at home and school.

A review of the snippets of the learners' experiences in the questionnaire revealed five major factors that revolve around the mobilization of laboratory experiments. These were generated based on the consolidated codes ranked in order following their frequency of repetition in the narrative responses. Laboratory anxiety, laboratory ease, laboratory enjoyment, laboratory concept formation, and laboratory independence are among the laboratory experiment factors. [Table 7] summarizes the rank of the experiential codes with their corresponding laboratory experiment factor category.

Table 7. Ranking of codes of experiences in the conduct of project HANDLE and its categorization based on identified laboratory experiment factor

Rank	Codes (Translated)	Category
1	*Bako makatakot* (Not fearful)	Overcoming Anxiety
2	*Madali gibuhon* (Easy to perform)	Ease
3	*Bako makakurab* (Not nervous)	Overcoming Anxiety
4	*Makaugma* (Fun)	Enjoyment
5	*Madali maukudan* (Easy to understand)	Concept formation
6	*Komportable mag-gibo* (Comfortable in the task)	Ease
7	*Kayang solohon* (Can be done alone)	Independence
8	*May mga bagong naaraman* (Learned something new)	Concept formation
9	*Madali gibuhon ang setup* (Easy to construct setups)	Independence
10	*Excited sa resulta* (Excited about the result)	Enjoyment

The most notable experience among the responses of the learners is the suppression of their anxiety about doing laboratory work. This was reflected based on the majority of consolidated behaviors manifesting the lack of fear and not feeling nervous about doing the laboratory activity. This was revealed from a comparison of a previous experience of trembling hands when transferring fluids to a more composed conduct of the activity using the mobilized laboratory manual. The majority of the learners' responses narrated that it was the keen expert supervision that pressures them, while the use of glassware makes them anxious when the laboratory activity is done at school. Examination of these anxiety-related factors could be attributed to the minimal laboratory immersion of learners, which makes them foreign to handling glassware, whereas pressure caused by attention and supervision from a teacher could mean personality inferiority. Nonetheless, the use of Project HANDLE is efficient in alleviating the experienced anxiety since the identified factors were unintentionally withdrawn from the intervention structure. Despite extensive literature evidence indicating a lack of attempt to overcome anxiety in laboratory activity [51][52], the current study provided sufficient evidence that self-directed laboratory activity is an effective method of addressing anxiety. Not only is this true for the present study, but there are also accounts in the literature indicating the meaningful contribution of self-directed learning to promoting success, readiness, and diminishing laboratory anxiety in chemistry [53].

Another factor observed from the experiential responses of the learners was their independence in doing laboratory work. This was reflected in two of the most cited codes "Can be done alone" and "Easy to construct setups". These codes show that the structure of the home-based laboratory experiment is grounded on the level of the learners' understanding, making it viable for them to perform the task alone. Moreover, the context of the developed home-based laboratory experiments made use of materials readily available at home and in the community, which allowed for the individualized conduct of the activity without dependence on a more knowledgeable peer. When a learner expresses his independence in the conduct of laboratory work, the development of SPS also occurs, provided that opportunities for each SPS are embedded in the task. This perhaps explains why learners emerged with superb levels of developed SPS despite doing the task alone. A review of the literature also showed some approaches that promote the development of independence in doing laboratory work. In a study conducted by Johnson et al. [54], they found that college learners were able to build independence in conducting research and develop the right levels of attitude for learning. The findings of the present study and those in the literature suggest that independence in conducting laboratory activities can be attained if innovative methodologies and out-of-the-box approaches are employed in the conduct of experiments. Optimal development of SPS is achieved when learners can perform laboratory activities independently.

Enjoyment is another factor observed in the cast of experiences reflected in the codes of the learners during the home-based laboratory experiments. Codes illustrated the majority of the responses in the codes of the learners during the home-based laboratory experiments. These revealed the common narratives as "fun" and "excited about the result," which somehow provide a little splash of independence and overcoming anxiety. This could mean that positive emotions of the learners can also lead to the development of knowledge and SPS, as shown in the improvement of learners' scores. When learners create a positive emotion towards science, they build interest and soon acquire knowledge. This was supported based on the assumption of the works of Haury and Rillero [55], who noted that enjoyment of learning science and independent thinking are products of a positive attitude. One of the observed elements as to why learners enjoyed the conduct of the home-based laboratory experiment is the contextualization of the materials; they are all available at home. It is true enough that learners shift their positive attitude towards a material if it has a significant relevance or connection to them. This is not only true in the conduct of laboratory experiments but also in a repertoire of proven facts from previous studies. In the study of Oraye [56], he noted that contextualization of materials improved the positive-attitudinal levels of learners, which accounts for their improved levels of understanding and skill acquisition. This proves that the use of materials known to the learner enhances the enjoyment and a shift in positive attitude in the acquisition of knowledge and skills in science. There are also accounts indicating the "enjoyment effect" of laboratory work, resulting in improved levels of attitude and interest in learning science [57]. This proves that laboratory enjoyment is a springboard, or an outcome, of a boosted SPS, along with other science domains.

The conceptual formation is also observed as one of the experiential factors of the learners in the conducted home-based laboratory experiment. This was shown in the codes expressed as "Easy to understand" and "Learned something new". The conduct of laboratory experiments truly aids in the development of scientific knowledge, as well as the achievement of process skills, the encouragement of scientific perception, and the development of different learning environments [58]. Alongside the development of knowledge, this also shows that SPS develops or vice versa. In the experiment, the learners used specimens from a hay infusion and the interior tunic of an onion bulb to test if the developed microscope worked. In the activity, the learners were able to understand the mechanism of how a microscope works by following the flexible feature of the experiment where learners needed to devise their water-droplet microscope and enhance the suggested design. This means that the opportunity for the learners to become hands-on and elastic in the experiment affects their levels of SPS. Many studies have also determined the quality of learning derived from laboratory activities [59], with a focus on conceptual understanding as measured by observable scientific change [60]. Although it is not well established whether it is the concept formation or the SPS that developed first, the use of home-based laboratory experiments provided the learners with maximum potential in developing both SPS and conceptual understanding/formation.

The last observed factor in the development of SPS through Project HANDLE is the experienced ease of doing the activities based on coded responses like "Easy to perform" and "Comfortable in the task". This would mean that the structure of the developed home-based laboratory experiment is grounded on the level of learners' understanding. Despite its simple and context-based nature, it resulted in the development of other laboratory factors like enjoyment, conceptual formation, overcoming anxiety, and independence that aid in the acquisition of SPS or vice versa. On a similar note, the same findings were obtained from the study of Townsend [61], who indicated that learners find the hands-on laboratory experiment easy, although some accounts in the literature indicate that home-based laboratory instruction is not easy nor difficult to carry out [62]. The reflected responses on the ease of the laboratory manual showed that careful structuring of a material is the key to a better understanding of the learners and their engagement in the task. Plotting and designing based on their level of understanding and needs are the keys to setting their entry point in the experiment. Therefore, when a material is easy to use for the learners, SPS develops; or when the SPS is well developed, they find the learning experiment easy to perform.

The overall impact of Project HANDLE was revealed to be significant in providing positive laboratory experiences. Thorough studies need to be conducted to fully understand whether it is the laboratory factor or the SPS that catalyzes the development of the other.

3.5. Proposed framework for science process skills development culled from the findings of the study

The study's findings provided insights into the development of SPS via the mobilization of laboratory experiments at home during the distance learning modality. This is an augmentation to the traditional model of the Department of Education (DepEd) where, oftentimes, laboratory experiments will be conducted in a laboratory room in a school. With the advent of the new normal in classroom instruction, the present study proved that the development of a laboratory manual aimed at mobilizing experiments can somehow develop SPS via independent learning without the utmost supervision from an expert. Thus, this proposed framework was developed to increase the likelihood of acquiring the target science domains, particularly in the conduct of laboratory experiments during distance learning.

The present study satisfied the existing framework of the science curriculum, particularly in the conduct of laboratory experimentation, to attain the development of SPS, which is one of the science domains. The proposed framework augmentation will serve as a benchmark to successfully implement laboratory-based instruction without compromising the quality of science learning.

One characteristic noted in the development of SPS is the hands-on feature of the material, where learners need to immerse themselves in their natural setup to experiment, hence contextualization. Therefore, the philosophy for the conduct of effective home-based laboratory instruction is grounded in naturalism and constructivism. The unison of these philosophies agrees that learners are capable of nurturing their knowledge and skills when the instruction is grounded in their nature. The application of these learning philosophies can be reframed using approaches related to nature and nurture. Two of the best approaches are through the use of contextualization and culture-based approaches, which have been long proven to trigger learning acquisition since learners are expected to learn best when the medium of instruction is of use or relevant to them. In addition, brain-based strategies may also be integrated. These learning approaches can be applied through the use of readily available objects or consumables found at home or cultural practices known to learners to establish a connection with the material. These approaches make the laboratory material viable for mobilization without maximum expert supervision unless it is quality assured with a simple yet powerful instructional guide to assure SPS development. Moreover, the structure of the laboratory manual must ensure equal opportunities for the development of every target SPS. [Figure 3] shows the overall proposed framework of the study based on its findings.

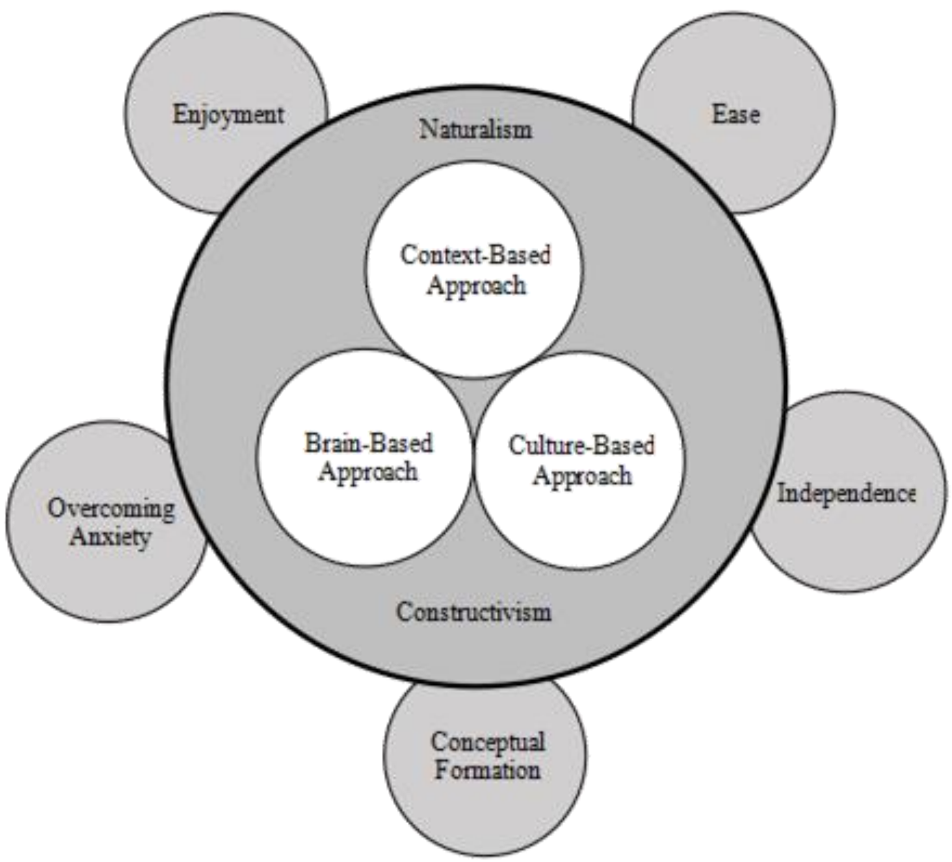

Figure 3. Framework for the use of context-based laboratory experiments during distance learning modality (home-based)

One characteristic noted in the development of SPS is the hands-on feature of the material where learners need to immerse themselves in their natural setup to experiment, hence contextualization. Therefore, the philosophy for the conduct of effective home-based laboratory instruction is grounded on naturalism and constructivism. The unison of these philosophies agrees that learners are capable of nurturing their knowledge/skills when the instruction is grounded in their nature. The application of these learning philosophies can be reared using approaches related to nature and nurture. Two of the best approaches are through the use of contextualization and culture-based approach which have been long proven to trigger learning acquisition since learners are expected to learn best when the medium of instruction is of use or relevant to them. In addition, brain-based strategies may also be integrated. These learning approaches can be applied through the use of readily available objects/consumables found at home, or cultural practices known to learners, to establish a connection to the material. These approaches make the laboratory material viable for mobilization without maximum expert supervision unless it is quality assured with a simple yet powerful instructional guide to assure SPS development. Moreover, the structure of the laboratory manual must ensure equal opportunities for the development of every target SPS.

Triangulation of the philosophies and approaches integrated into the development of a laboratory manual for home-based experiments will surely develop positive attitudes and experience in learning science skills. This framework for learning SPS is proposed for implementation/adaptation across all grade levels since the framework is holistic and appropriate for all ages.

4. Conclusion

The study aims to assess the effectiveness of Project HANDLE in developing the SPS of Grade 7 learners. It was shown that Project HANDLE is effective in developing the basic SPS when features of grounding on the means of living of the learners were integrated into the design of the intervention. Further, the intervention has also shifted several attitude-related factors in conducting experiments, like overcoming anxiety, ease, conceptual formation, independence, and enjoyment. Considering the usage of school-based laboratory experiments in establishing SPS, Project HANDLE may be viewed as an alternate tool in SPS development, particularly for distant learners. This outcome is not only of significance to teachers, learners, and module writers, but it is also inclusive to educational reformers in terms of providing other alternative modes of learning.

Probing the effectiveness of Project HANDLE, the intervention holds promising implications for the future modes of laboratory conduct and implementation via distance learning episodes through self-directed learning without thorough monitoring from an expert. It is also crucial to remember that Project HANDLE outcomes are only relevant in the research locale since its contents employ local examples and cultures that the respondents are familiar with. Therefore, future researchers may also develop a Project HANDLE using the context of the school locale where they wish to implement their intervention.

5. Recommendations

Although positive learning outcomes were recorded in the study, the following concerns need to be addressed to strengthen the claims and findings of the work: (1) alter the methodology by doing a quasi-experiment comparing the effects of SPS development of home-based versus laboratory-based experiments; (2) further investigate whether it is the positive laboratory attitude or the SPS acquired that serves as an antecedent of the other; (3)

implement the Project HANDLE in a different context to determine if its effect runs parallel to the ones in the research locale; (4) measure the level of positive attitude developed in the experiences of learners using a Likert scale; (5) use Project HANDLE to measure integrated SPS; and (5) implement the proposed framework in the form of another action research.

Author's Notes

This research was obtained from the original action research report of the author, which was approved and submitted to the Schools Division Office of Albay (SDO-Albay), Department of Education, the Philippines. The publication of the final version of this research was approved by the rightful authorities of the office.

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