Grade 12 STEM Students' Perceptions and Experiences in Home-grown Chemistry Experiments

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Abstract: The COVID-19 pandemic has forced many countries to declare lockdowns and quarantines. This caused the education system to shift to remote learning, wherein some schools adopted home-grown chemistry experiments to facilitate the learning experience. Through a descriptive research survey, students' perceptions and experiences in home-grown experiments were determined. The survey's item reliability was found to have a Cronbach alpha of 0.65. Based on the mean scores of the responses, the respondents showed a negative outlook about their experiments as they express their disinterest and troubles about material preparation and lack of collaborative work. Though students agreed that laboratory activities are clear, and the materials needed are easy to use, they were hesitant to ask for help from their teacher about the activities. Further, there is no difference in students' perceptions and experiences in terms of gender. The distribution of percentage frequencies of the responses for both male and female students have similarities, and the computed p-values support these, which are 0.85, 0.83, 0.99, 0.75, and 0.88 (> 0.5) on each category on the survey. Overall, 52% of the total respondents were able to complete and passed all the activities. While 34% have incomplete submissions, and 8% never submitted their outputs. These reports were found valuable in conducting home-grown experiments for distance learning in senior high school's general chemistry.

Keywords: home-grown experiments; STEM; general chemistry; perceptions; experiences

1. INTRODUCTION

Laboratory course works have been believed to be an essential part of learning in science education. It provides a first-hand experience in observation and manipulation of scientific materials, which builds and hones students' providing skills, practical skills, scientific skills, and general skills (Reid & Shah, 2007; Bernhard, 2018; Bretz, 2019). The importance of laboratory course works could be associated with *variation theory*. This theory states that learning is a process of developing abilities and values that help a learner to face different situations effectively (Kullberg, Kempe & Marton, 2017). Having varied experiences made people discern things uniquely. Therefore, learning is influenced by variation patterns situated in an experience or observation. This theory believes that learning is composed of discernment, simultaneity, and variation which is apparent in laboratory course works.

Subsequently, the COVID-19 pandemic has forced many countries to declare lockdowns and quarantines. This also forced the education system to transition from face-to-face learning to remote learning. Remote learning however became a challenge for STEM-related subjects, particularly in the laboratory course works. Simulations and videos have been an option to compensate for actual laboratory work to deliver high-quality learning in midst of a pandemic. However, arguments that learning is nurtured by personal, authentic, inquiry-based, and hands-on experiences are still in debate as well as the financial, and logistical concerns for providing students with laboratory experiences (Kelly, 2020). These issues are evident in a third-world country, like the Philippines. Still, most schools practiced the modular approach in consideration that students struggle with gadgets and internet access. Thus, home-grown experiments were used which are cost-effective because the materials are based on common households.

As such this paper aims to discuss the perceptions and experiences that grade 12 STEM students had in their home-grown experiments in general chemistry.

2. METHODOLOGY

A descriptive survey research design was used to address the concern about the perceptions and experiences of Grade 12 STEM students with home-grown experiments in Chemistry. This was done through an online survey using google forms. Through the permission of the school's department head 187 grade 12 STEM students from a private school in Taytay, Rizal participated voluntarily in the online survey. Of these, 90 are male and 97 are female students. The scope of this survey was the 1st trimester of General Chemistry 1 (September – December 2020).

To address the research objectives a 4-point Likert scale survey was used (1 – strongly agree, 2 – agree, 3 – disagree, 4 – strongly disagree) to determine students' perception and experiences which were prepared by the researcher. The crafted survey is composed of 14 statements about students' perceptions which are categorized as the positive and negative outlook towards their home-grown experiments while another 14 statements about students' experiences that are categorized as nature of activity and nature of skill. The preparation of the survey statements was guided by various research papers (Gendjova, 2007; Kelly, 2020; Smith *et al.,* 2013) and was validated by three teachers who are experts in chemistry and distance learning. The item reliability of the survey was determined using Cronbach alpha and was found to be $\alpha = 0.65$.

Moreover, mean, standard deviation, and percentages were used for the descriptive analysis of data. The significant difference in terms of gender was determined using a two-tailed t-test through JMP statistical software.

3. RESULTS AND DISCUSSION

Home-grown experiments have been used as an alternative to laboratory experiments (Kennepohl, 2000). It increases students' interest as they encounter tools and materials that are more common to their understanding (Nja *et al,* 2020, Cox, 2019). In these results and discussions, the perceptions, and experiences of the students about home-grown experiments in chemistry will be discussed.

Table 1. The Mean and Standard Deviation of Responses on Students' Perception (N = 187)

	Statements	Mean	SD	Remarks
Positive outlook towards the given activity				
S1	It was exciting to do experiments at home during the quarantine.	2.42	0.81	Agree
S2	I felt more engaged in doing the experiments at home (remotely) because I do it alone.	2.52	0.84	Disagree
S3	I felt at ease because the materials are common at home.	2.53	0.72	Disagree
S4	I believe that the set-ups I did during the experiments are reliable.	2.28	0.67	Agree
S10	I am fully satisfied with the experiments we have done at home.	2.26	0.67	Agree
Negative outlook towards the given activity				
S5	I preferred doing experiments that develop teamwork.	1.98	0.75	Agree
S6	It was inconvenient for me to schedule my experiments.	2.07	0.71	Agree
S7	I felt worried about how to prepare my experiments.	2.21	0.68	Agree
S8	I was disappointed with the outcomes/results of my experiments.	2.75	0.79	Disagree
S9	I am not interested in the experiments that we are required to accomplish.	2.02	0.67	Agree
S11	I believe that I will learn better in actual laboratory experiments instead of the alternative materials at home.	2.27	0.73	Agree
S12	I am not confident with the home-grown experiments that I have done in chemistry.	2.07	0.74	Agree
S13	I preferred videos or virtual simulations in doing experiments rather than homegrown experiments.	2.20	0.77	Agree
S14	I felt uncomfortable asking clarifications about the experiments.	2.22	0.71	Agree

3.1 The Students' Perceptions and Experiences about their Home-grown Experiment

Based on the data in table 1, students exhibit negative perceptions towards their home-grown experiments wherein they expressed disinterest in accomplishing their activities. Students also expressed their struggle in scheduling their experiments though they agree that they are excited about their experiments and believed that the activity guides were reliable. It was observed that they are also worrisome in gathering the materials needed and also believed that the experiments are more engaging if they could do it with their classmates. Moreover, students believed that actual laboratory experiments are more reliable and preferred virtual simulation or videos as an alternative for laboratory course works. Lastly, they are also uncomfortable to ask help in doing their activities.

These responses are contrary to what was conveyed in Lyall & Patti's (2010) and Kennepohl's (2007) studies which claimed that students who had experiments at home expressed good reactions and performances compare to those who are taking laboratory experiments at university. On the other hand, Kelly's (2020) paper supports the data presented in table 1. Based on her paper the collated reflections of her students about their home-based chemistry experiments mostly expressed phrases such as "you might not have the materials you need", "you cannot redo it if you mess up or spill materials", and "you cannot look at what another student is doing". These are some of the aggregated feedbacks she had that were aligned with the negative perceptions of the respondents such as non-confidence with the accomplished activities, and uneasiness about the availability of materials. Also, Reeves & Kimbrough's (2004) paper, emphasized that a successful kitchen chemistry experiment (or home-grown experiment) in distance learning should have a well-organized calendar, which could have helped the students in managing their schedules.

Table 2. *The Mean and Standard Deviation of Responses on Students' Experiences (N = 187)*

Statements		Mean	SD	Remarks
Nature of the Activity				
	Experiences while preparing for the experiment			
S1	The instructions given were clear.	1.98	0.50	Agree
S2	The instructions were easy to follow while experimenting.	2.08	0.56	Agree
S4	It was easy to gather the materials that I needed for the experiments.	2.76	0.70	Disagree
	Experiences while experimenting.			
S3	The time allotted to experiment was enough for me to accomplish.	2.20	0.66	Agree
S11	The materials were easy to use and engaging.	2.20	0.52	Agree
S13	I easily understand the practical importance of my experiments because the materials are familiar.	2.22	0.61	Agree
	Experiences after the experiment.			
S7	The experiments helped me identify whether my formulated hypothesis was acceptable or not.	2.02	0.59	Agree
S8	I was able to arrive at the expected outcome accurately.	2.26	0.55	Agree
S9	The provided experiment guidelines helped me achieve the learning outcome that I needed.	2.07	0.56	Agree
Nature of Skill				
S5	I had a hard time setting up my experiments.	2.24	0.69	Agree
S6	I do not understand the provided guidelines so I cannot accomplish the experiment.	2.70	0.60	Disagree
S10	I had a hard time interpreting the data that I gathered during the experiments.	2.22	0.69	Agree
S12	I cannot design a good laboratory report because the outcome of my experiments does not align with the guide questions provided.	2.42	0.68	Agree

On the other hand, table 2 shows that students experienced struggles in gathering and preparing their materials. Though, they agreed that they had enough time to do the activities and were able to understand the practical importance of what they have done. Students also agreed that the instructions and guidelines given are easy to understand and the materials required are easy to use and engaging. However, they could still not accomplish their outputs because they were struggling in interpreting the results of their experiments. This problem in their experiences might be caused by being uncomfortable to ask for assistance and clarification from their teacher. Therefore, teachers could not instruct the students and catch their errors remotely. This problem is also emphasized in some studies (Faulconer & Gruss, 2018; Reeves & Kimbrough, 2004) where students do their experiments remotely hence, they could not convey timely questions.

Moreover, students believed that the crafted guide questions in their worksheets are not aligned with the experiments, but they were able to arrive at accurate results and validate their hypotheses. These reflect possible confusion at the end of the students about the essence of guide questions in a laboratory guide. These responses about students' experiences are also aligned with Kelly's (2020) paper. Her research reported some of the reflections from her students such as, "laboratory remind you why chemistry is cool and useful". This supports the agreed response about understanding the importance of their accomplished experiments which is possibly caused by the familiarity of the materials used.

3.2 The Students' Perceptions and Experiences in Terms of Gender

Tables 3 and 4 summarized the percentage of responses in both male and female respondents. It is shown that both male and female students have almost the same distribution of frequency of responses and revealed that they have the same perceptions and experiences. An average of 55% of male respondents and an average of 53% of female respondents agreed with items 1,3,4 and 10 under positive outlook. Both male and female students disagreed on item 2 which is about 46% and 38%, respectively. In terms of the negative outlook, it is numerically evident that majority of males and females disagree on item 9 which is 71% and 61%, respectively, while the rest of the items were agreed by the majority of males and females. The frequencies show that there is no difference in terms of gender and is supported by t-test analysis. The computed p-values were 0.85 and 0.83 respectively, for the positive and negative outlook of students in terms of gender. While the p-values in terms of experiences, before, during, and after the experiment is 0.99, 0.75, and 0.88 which pertain to the nature of the activity, and a p-value of 0.66 in terms of the nature of their skills. These stated p-values are above 0.5 level of confidence thus, there is no significant difference in terms of their gender.

Table 3. *Percentage of Item Frequencies on Students' Perceptions in terms of Gender (N = 187)*

	% MALE				% FEMALE			
Item No.	S (1)	A (2)	D (3)	SD (4)	S (1)	A (2)	D (3)	SD (4)
Positive outlook towards the given activity								
S1	10	50	29	11	11	42	38	8
S2	10	34	46	10	13	36	38	12
S3	3	48	42	7	4	49	34	12
S4	6	61	31	2	7	64	24	5
S10	8	62	24	6	10	57	31	2
Negative outlook towards the given activity								
S5	36	52	10	2	31	50	15	4
S6	12	56	31	1	7	49	37	7
S7	26	60	12	2	29	56	14	1
S8	12	38	42	7	11	40	41	7
S9	4	13	71	11	3	19	61	17
S11	53	36	9	2	48	43	5	3
S12	21	51	27	1	24	49	25	2
S13	24	47	27	2	25	47	26	2
S14	31	56	12	1	36	49	11	3

Table 4. *Percentage of Item Frequencies on Students' Experiences in terms of Gender (N = 187)*

	% MALE				% FEMALE			
Item no.	S (1)	A (2)	D (3)	SD (4)	S (1)	A (2)	D (3)	SD (4)
Nature of the Activity								
Experiences while preparing for the experiment								
S1	14	73	12	0	11	77	11	0
S2	13	67	20	0	11	69	20	0
S4	4	26	59	11	3	31	54	12
Experiences while preparing for the experiment								
S3	13	56	29	2	10	59	30	1
S11	6	77	17	1	3	69	27	1
S13	6	63	29	2	11	61	27	1
Experiences while preparing for the experiment								
S7	16	67	18	0	16	66	16	1
S8	4	63	32	0	5	65	29	1
S9	10	72	17	1	13	67	20	0
Nature of Skill								
S5	15	56	28	2	10	53	34	3
S6	2	34	57	7	1	30	64	3
S10	11	56	31	2	16	49	33	2
S12	11	44	44	0	4	49	40	7

* S- strongly agree, A – agree, D – disagree, SD – strongly disagree; Male = 90, Female = 97

These findings are opposing with Antonovics *et al's* (2009) study. They find out that there is a difference among the students' perceptions and experiences in their laboratory coursework in terms of gender. This observed difference was affected by the class interaction. Tension and competition among the students also added to the environment which caused different reactions drawn from male and female students during the engagement. Thus, it is appropriate to assume that due to lack of interaction during remote learning, students will not encounter any difference in their perception and experiences in terms of gender. This is because they will not have the privilege to discuss and share their ideas with their classmates about the observations, experiments, and claims that they have drawn.

3.3 The Students' Performances

The students had five sets of laboratory experiments within three months of the first trimester. Table 5 shows that most of the students were not able to completely submit their outputs on limiting and excess reagents which is a four-page worksheet. It is possible because it was their first experiment for the term and are still adjusting to the remote learning set-up. Still, this report shows that only 57 students were able to complete and passed the said activity which is only 30% of the respondents. This could also be related to the problems in learning stoichiometry. Therefore, the low frequency of completed and passed experiments about limiting and excess reagents could also be due to the unmastered concepts and skills about the topic. Nevertheless, an improvement was observed on activities about the nature of water, concentrations, and neutralization reaction. Students who completed and passed the said worksheets are around 70% of the respondents, or 131, 114, and 133 students out of 187 respondents, respectively. However, a decrease in completers was observed in the last experiment about identifying pH. This may suggest that teachers need to do additional follow-up and assistance, for the remaining 10-30% of students who did not complete and passed the activities. Overall, 52% of the total respondents were able to accomplish and passed all the activities. While 34% have incomplete submissions, and 8% never submitted their work.

Table 5. *Frequency of Students' Submission and Performances on the Home-grown experiments (N=187)*

	Laboratory Activities				
	Lmt'g and Excess reactants	Nature of Water	Concen-trations	Neutralization Rxn's	Identifying pH
Number of pages	4	1	2	1	2
COMPLETE					
passed	57	131	114	133	104
failed	72	21	15	16	27
INCOMPLETE	34	0	2	0	6
UNSUBMITTED	24	35	56	38	50

The submission tally report reflects the same observation with Kelly (2020) and Schultz *et al* (2020). Their submission reports and activity scores are also low, especially on the report of Schultz *et al* (2020) wherein they compare the submission and performance of the students during their face-to-face classes. This indicates that remote learning is difficult for some students. This may be caused by the difference between the rules implied in the traditional laboratory and home-based experiments. This suggests that students need more support and time in completing their outputs.

4.CONCLUSIONS

The home-grown chemistry experiments have been a useful alternative for distance education. However, a loss of interest was observed in the students' responses. Though they found the experiments exciting, they agreed on statements that communicate problems about the availability of materials, scheduling their activities and lack of collaborative work. They also express their agreement on using simulations and videos instead of home-grown experiments as well as being uncomfortable to ask their teacher. In terms of experiences, they struggled with preparing the required materials but agreed that the provided activities have clear instructions, the materials were easy to use, and they were able to arrive at accurate results However, they struggled to understand the activities, set up the experiments, and do the post-laboratory reports.

Thus, ways to lessen the burden in resources, as well as strategies to increase students' interest, must be determined. Possible ways to deal with the observed problem about students' perceptions and experiences in home-grown activities is through simplifying the experiments into smaller scales. Peer-reviewing of laboratory outputs may help in building class interaction as well as allowing students to do their tasks in pairs or small groups. Letting students distribute tasks with their classmates even not face-to-face may also help them in developing laboratory skills, and increase output submissions provided that enough time is given to accomplish work as a group. Still, further research is needed about conducting home-grown experiments for remote learning.

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