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Assessing Learners' Level of Understanding Electrochemistry Using Self-Assessment Checklist: A Basis in Designing Learning Packets

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Abstract:
This research aimed to assess learners' level of understanding of electrochemistry using a self-assessment checklist. The participants were composed of 187 Grade 11 STEM learners identified through convenience sampling. The frequency and percentage showed learners' prior knowledge of the concept of electrochemistry. The mean and standard deviation showed learners' level of understanding of electrochemistry using a self-assessment checklist that determined that they know and can do the entire learning target without making mistakes. The t-test for paired samples showed the following results: (1) there is a significant difference between the pretest and post-test scores of Grade 11 STEM learners; (2) there is no significant difference between the post-test mean value and learners' level of understanding electrochemistry based on the Most Essential Learning Competencies. The researchers recommend designing a learning packet based on the learning targets as a learning material to increase learners' level of understanding of electrochemistry.

Keywords **—Electrochemistry, Level of understanding, Self-assessment checklist, Most essential learning competencies**

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INTRODUCTION
The school year 2020-2021 has been one of the most challenging academic years in the Philippines and worldwide. There is a shift in education from face-to-face classes to different modalities, like the online and modular approaches to learning. Online learning caused a change from a traditional to a cyber-learning environment as one of the modalities during the pandemic [1]. Technology allows today's learners to study at their own speed [2,3,4]. According to a source [5], technology is essential to the creation of curricula. Monitoring pupils' learning and conceptual understanding was one of the biggest issues facing teachers.

The improvement of students' comprehension and use of scientific knowledge is one of the objectives of the nation's science education system. According to a study [6], critical thinking, which was based on learners' 21st-century competencies, would be another crucial ability required. A study [7] claims that science works with intricate, varied topics. While Electrochemistry is one of the topics covered in General Chemistry 2 for Senior High School, General Chemistry is one of the specialized disciplines under the Science, Technology, Engineering, and Mathematics (STEM) strand.

The curriculum guide specifies the learning objectives for each lesson. These learning competencies are related to the goals or learning objectives that the students are meant to reach. During this pandemic, these learning competencies were crammed in and given the name Most Essential Learning Competencies (MELCs). According to [8], subject knowledge

is crucial to the learning process of students. Different types of learners' conceptual knowledge develop because of the nation's efforts to improve the efficacy and quality of education.

Previous research identifies that using a learning checklist provides and supports students' understanding of the concepts. This research aimed to assess students' level of understanding of chemistry concepts using a learning checklist. Specifically, this study aimed to identify students' prior knowledge of the chemistry concepts of electrochemistry. Identify the significant difference between the pretest and posttest and the significant difference between the posttest and the learners' level of understanding electrochemistry using a self-assessment checklist. In addition, this also aimed to assess students' level of understanding of the chemistry concepts: electrochemistry after the instructions using a self-assessment checklist. Lastly, this aimed to design a learning packet that will help students understand the concept of electrochemistry.

Electrochemistry and learners' level of understanding

DepEd Order No. 31 s.2012 [9] designates General Chemistry 1 & 2 as a specialist subject for the Science, Technology, Engineering, and Mathematics Strand of the K to 12 Basic Education Program in the Philippines. In DepEd Order No. 012, often referred to as the adaptation of the Basic Education Learning Continuity Plan in light of the COVID-19 Public Health Emergency, the learning competencies from all domains were condensed into the most important learning competencies [10]. The fourth quarter of General Chemistry 2 principles, particularly electrochemistry, is covered. The ten (10) most important learning competencies for the subject of electrochemistry are listed below.A study [11] claims that the background of chemistry has a lot of abstract ideas that are hard for students to comprehend since they involve macroscopic, microscopic, and symbolic notions.

In electrolysis and voltage cells, electrochemistry is the process of converting chemical and electrical energy [12]. According to [13], electrochemistry is difficult for most students and gets bad reviews. According to a study [14], students' difficulties with learning electrochemistry can be broken down into two main categories: the inability to explain chemical reactions in detail and the inability to connect the macroscopic, submicroscopic, and symbolic entities—or any combination of the two—to one another. According to reports, there are a variety of instructional strategies for electrochemistry that can improve students' conceptual comprehension [15]. According to the study [16],[17], there are gaps between students' everyday knowledge of electrochemistry and the curriculum; as a result, the students' conceptual grasp of this subject could be addressed by planned instruction that includes fine-grained practical exercises.

Self-assessment checklist

In a study [18], the term "self-assessment" has been used to describe a wide variety of activities, including putting a happy or sad face on a story you just heard, estimating how many questions on a math test will be correct, graphing dart throwing scores, demonstrating understanding of a scientific concept, identifying the strengths and weaknesses of a persuasive essay, writing reflective journal entries, and more. In terms of both the accuracy of students' self-assessment and their influence on learning and performance, study findings that would otherwise appear to be at odds with one another can be interpreted thanks to the goal of self-assessment [20].Theories of learning's self- and co-regulation serve as the foundation for new ideas of self-assessment [21]. Self-assessments have been recommended as a way to inspire and involve students in their learning [22]. Self-evaluation increases students' motivation and interest, which results in more learning and higher academic achievement as well as the development of their analytical and critical thinking skills [23]. Other self-assessment methods are self-assessment sheets, checklists, and portfolios, according to a reference [24]. According to a study [25], students found checklists to be less intimidating and started to feel more responsible.

OBJECTIVES OF THE STUDY

In view of the objective, which aimed to assess students' level of understanding of chemistry concepts using a learning checklist, the researchers answered the following questions.

1. What is the students' prior knowledge of the chemistry concepts of electrochemistry?
2. Is there a significant difference between the pretest and posttest scores?
3. What is the level of understanding of Grade 11 STEM students on the chemistry concepts, specifically electrochemistry, based on the most essential learning competencies?
4. Is there a significant difference between the students' mean posttest scores and their level of understanding based on the most essential learning competencies?
5. What measures can be taken to increase learners' level of understanding of the concept of electrochemistry?

II. Materials and Methods

Research Design

In this study, two variables were measured, and their statistical relationships were examined using

descriptive non-experimental research, namely correlational research [27].

Sample and Setting

For the academic year 2021–2022, 187 students in grade 11 at senior high schools were taken into consideration. The respondents were from the Science, Technology, Engineering, and Mathematics strand of one of the private universities in Angeles City, Pampanga. The respondents were selected through convenience sampling. The sampling method was used since the data collection procedure was conducted online.

Instruments

The twenty (20) item pre-posttest was created by the researchers to gauge learners' prior understanding of the electrochemistry subject. The Department of Education has given a self-assessment checklist based on the core learning competencies with a 0–4 scale of Marzano's understanding [28].The three experts in the field validated the pre-posttest and self-assessment checklist before the actual assessment. Based on the pilot testing, the reliability coefficient of the concept test was 0.783 using Cronbach's alpha model.

Data Collection and Procedure

The data was collected through google forms. The data collection happened between March and April then afterward, thorough analyses were carried out utilizing the gathered data.

Data Analysis

The pre-posttest data were compiled and calculated using the mean value. Additionally, the researcher used a 0–4 point scale [28] to gauge how well students understood chemical concepts. The meaning of the score of (3) is "I know and can do the entire learning target without making mistakes," the meaning of (2) is "I know and can do the easy parts, but I don't know and can't do the harder part," the meaning of (1) is "With help, I know and can do some of the learning targets," and the meaning of (0) is "I don't know, and can't do any part of the learning target."

In the statistical treatment of data, descriptive statistical tools were used by the researcher, wit:

Norm of Interpretation

FIVE-POINT SCALE ON THE LEARNERS' LEVEL OF UNDERSTANDING OF CHEMISTRY CONCEPTS: ELECTROCHEMISTRY

Rating	Response Category	Range Interval
4	I know and can do the learning target well enough that I can make connections that were not taught to me	3.50-4.00
3	I know and can do the entire learning target without making mistakes	2.50-3.49
2	I know and can do the easy parts, but I don't know and can't do the harder part	1.50-2.49
1	I know and can do the easy parts, but I don't know and can't do the harder part	1.00-1.49
0	I don't know and can't do any part of the learning target.	0.00-0.49

Frequency and percentage were utilized to determine learners' prior knowledge of the topic of electrochemistry. The self-assessment checklist used the mean and standard deviation to describe the learners' level of understanding of electrochemistry. Furthermore, a t-test for paired samples was utilized to determine the significant difference between the learners' pretest and posttest scores; and the significant difference between the posttest and learners' level of understanding based on the most essential learning competencies.

Ethical Consideration

The researchers adhered to the ethics that the researchers observed. Before the actual gathering of information, the researcher asked for the approval of the Basic Education Principal, and informed consent was given to learners. The profile of the students remained anonymous. The respondents were informed of their right to withdraw from this study whenever they wished to do so. This study intends no harm to the participants.

III. Results and Discussion

The following were the results of the study based on the sequence in the statement of the problem.

Table 1 shows the frequency and percentage of learners' prior knowledge of the concept of electrochemistry. On MELC 1: Define oxidation and reduction reactions, 64 out of 187 or 34.22 % of learners answered the items correctly. MELC 2: Balance redox reactions using the change in oxidation number method 53.48 % or 101 out of 187 learners responded correctly to the given questions. MELC 3: Identify the reaction occurring in the different parts of the cell 107/187 or 57.22 % of learners answered the items accurately. MELC 4: Define reduction potential, oxidation potential, and cell potential 16.58 %, or 31 out of 187 learners were correct on the questions provided. MELC 5: Calculate the standard cell potential. Only 41/187 or 21.93 % of learners answered the questions right. Apparently, on MELC 6: Relate the value of the cell potential to the feasibility of using the cell to generate an electric current, 44 out of 187 or 23.53 % of learners answered the given items accurately. 33 out of 187 or 31.02 % of learners responded to the items on MELC 7: Describe the electrochemistry involved in some common batteries: a. Leclanche dry cell b. Button batteries c. Fuel cells d.

Lead storage battery, correctly. 17.65 % or 33/187 learners responded to the questions on MELC 8: Apply electrochemical principles to explain corrosion accurately. 63 out of 187 or 33.69 % of learners answered the items on MELC 9: Explain the electrode reactions correctly during electrolysis. Moreover, lastly on MELC 10: 51 out of 187 or 27.27 % of learners responded accurately. Based on the frequency and percentage of learners' correct answers, only a few have prior knowledge of MELCs 4 and 5.

TABLE I
FREQUENCY AND PERCENTAGE OF CORRECT ANSWERS IN ELECTROCHEMISTRY

MELCs	Frequency,f	Percentage (%)
1. Define oxidation and reduction reactions.	64	34.22 %
2. Balance redox reactions using the change in oxidation number method.	101	53.48 %
3. Identify the reaction occurring in the different parts of the cell.	107	57.22 %
4. Define reduction potential, oxidation potential, and cell potential.	31	16.58 %
5. Calculate the standard cell potential.	41	21.93 %
6. Relate the value of the cell potential to the feasibility of using the cell to generate an electric current.	44	23.53 %
7. Describe the electrochemistry involved in some common batteries: a. Leclanche dry cell b. Button batteries c. Fuel cells d. Lead storage battery.	58	31.02 %
8. Apply electrochemical principles to explain corrosion.	33	17.65 %
9. Explain the electrode reactions correctly during electrolysis.	63	33. 69 %
10. Describe the reactions in some commercial electrolytic processes.	51	27.27 %

Table 2 reflects the t-test for paired samples between the pretest and posttest scores of the learners. The learner's pretest mean value was 6.34 ± 2.62, and the posttest mean value was 10.79 ± 4.74 compared using a t-test for paired samples, resulting in a t-value of .366 α .000, which indicated that it is significant, hence the null hypothesis was rejected. After the synchronous and asynchronous session, there was an increase in the posttest scores compared to the pretestscores, which means that the intervention provided helped the learners increase their understanding of the concept of electrochemistry.

TABLE II
MEAN COMPARISON BETWEEN PRE-TEST AND POST-TEST SCORES

Test Type	Mean	SD	t-value	Sig. value	Interpretation	Decision
Pretest	6.34	2.62	.366	.000	Significant	Reject
Posttest	10.79	4.74				
α=0.05		Level		of		Significance

Table 3 shows the mean and standard deviations for the learners' level of understanding of electrochemistry using the self-assessment checklist yielded a total mean value of 2.78 ± 0.85 which means that based on learners' self-assessment of the concept of electrochemistry after the synchronous and asynchronous activities indicates that they know and can do the entire learning targets without making mistakes. Out of the most essential learning competencies, explaining the electrode reactions during electrolysis appeared with the lowest mean value of 2.56 with a standard deviation of 0.85. On the other hand, MELC number 1 defines oxidation and reduction reactions resulting in a mean value of 3.15 with a standard deviation of 0.77. The self-assessment checklist helped students evaluate their progress in learning the concept of electrochemistry. According to a study [14], students' difficulties with learning electrochemistry can be broken down into two main categories: the inability to explain chemical reactions in detail and the inability to connect the macroscopic, submicroscopic, and symbolic entities—or any combination of the two—to one another. Results were considered if students could complete the entire learning objective without making any mistakes but had trouble connecting each learning ability to describe the corresponding process. Research revealed that students felt less threatened by checklists and gained a sense of responsibility as a result [25]. Self-assessments have been recommended as a way to inspire and involve students in their learning [22]. Students were able to determine how well they understood the idea thanks to the self-assessment checklist.

TABLE III
LEARNERS' LEVEL OF UNDERSTANDING OF ELECTROCHEMISTRY USING SELF-ASSESSMENT CHECKLIST

Electrochemistry concepts based on MELCs	Mean	SD	Interpretation
1. Define oxidation and reduction reactions.	3.15	0.77	Learners know and can do the entire learning target without making mistakes.
2. Balance redox reactions using the change in oxidation number method.	2.71	0.88	Learners know and can do the entire learning target without making mistakes.
3. Identify the reaction occurring in the different parts of the cell.	2.77	0.80	Learners know and can do the entire learning target without making mistakes.
4. Define reduction potential, oxidation potential, and cell potential.	2.91	0.85	Learners know and can do the entire learning target without making mistakes.
5. Calculate the standard cell potential.	2.90	0.92	Learners know and can do the entire learning target without making mistakes.
6. Relate the value of the cell potential to the feasibility of using the cell to generate an electric current.	2.58	0.82	Learners know and can do the entire learning target without making mistakes.
7. Describe the electrochemistry involved in some common batteries: a. Leclanche dry cell b. Button batteries c. Fuel cells d. Lead storage battery.	2.81	0.88	Learners know and can do the entire learning target without making mistakes.
8. Apply electrochemical principles to explain corrosion.	2.73	0.87	Learners know and can do the entire learning target without making mistakes.
9. Explain the electrode reactions during electrolysis.	2.56	0.85	Learners know and can do the entire learning target without making mistakes.
10. Describe the reactions in some commercial electrolytic processes.	2.63	0.87	Learners know and can do the entire learning target without making mistakes.
Overall	2.78	0.85	Learners know and can do the entire learning target without making mistakes.

Table 4 illustrates the significant difference between posttest and level of understanding based on MELCS, resulting in a posttest mean value of 10.79 ± 4.74 and MELCS concepts mean value of 2.78 ± 0.67 compared using a t-test for paired samples, resulting in a t-value of .046 with a probability value of 0.528. Hence, the null hypothesis is accepted. Based on the posttest results, it can be gleaned that the intervention helped the students increase their understanding of the concept. However, it appeared similar to the results of learners' level of understanding using a self-assessment checklist which determined that learners know and can do the entire learning target without making mistakes. This showed that a self-assessmentchecklist could be an alternative evaluation tool to identify whether the learners understand a particular concept. Reference [23] agreed that self-assessment raises students' interest and motivation, leading them to increased learning and better academic performance and developing their critical skills for analyzing their work.

TABLE IV
SIGNIFICANT DIFFERENCE BETWEEN POSTTEST AND LEARNERS' LEVEL OF UNDERSTANDING BASED ON MELCS

Test Type	Mean	SD	t-value	Sig. value	Interpretation	Decision
Pretest	10.79	4.74	.046	.528	Not Significant	Accept
MELCs concepts	2.78	0.67				
α=0.05		Level		of	Significance	

IV. Conclusion and Recommendation

The following are the conclusion of the study:

1. Based on the frequency and percentage of learners' correct answers, only a few have prior knowledge of MELCs 4 and 5.
2. There is a significant difference between the pretest and posttest scores of Grade 11 STEM learners.
3. Based on the self-assessment checklist, the learners' level of understanding of Electrochemistry determines that they know and can do the entire learning target without making mistakes.
4. There is no significant difference between the posttest mean value and learners' level of understanding electrochemistry based on the most essential learning competencies.

The researchers recommend the following:

1. Revisit the science curriculum and assess the vertical and horizontal articulation of chemistry concepts, particularly the pre-requisite topics of electrochemistry.
2. Assess learners' level of understanding of general chemistry concepts qualitatively.
3. Use a self-assessment checklist as an evaluation tool to identify learners' progress in chemistry concepts or science topics in general.
4. Design a learning packet based on the learning targets of the concept of electrochemistry as supplemental material to increase learners' level of understanding and evaluation score results.

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