Digital literacy and innovative assessment techniques in instructional delivery of Chemistry in an online distance learning modality

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Abstract

Educators are seeking new ways to improve education with the underlying objective of improving learning. The ways of improving and requiring the necessary skills are observed to vary from one student to another. It includes creative and innovative ways of assessing learning progress and providing feedback and interaction effectively under adverse circumstances with the aid of digital tools and resources. Thus, great considerations in ensuring the reliability and authenticity of innovative assessments while utilizing online distance learning are another challenge that educators must be facing. Empowering conceptual understanding, creativity, and innovative minds to provide reliable assessments through feedback or interaction is the undertaking of this study.

The study employed a descriptive-developmental research design. This method was the most appropriate since the study dealt with finding the effectiveness of digital literacy and innovative assessment techniques in the instructional delivery of chemistry in an online distance learning modality. The participants of this study were Forty (40) Grade 8 Level students at San Pedro National High School. This involved two (2) online distance learning modality sections of the grade 8 level composed of 20 students in each section. The instruments that were utilized to obtain the needed data were a questionnaire for digital literacy skills and a researcher-made test to measure the performance of learners before and after the experiment.

Innovative assessment techniques such as feedback and interaction were proven effective in the development of conceptual understanding of the students in the instructional delivery of Chemistry under the online distance learning modality. More importantly, there is a significant difference in the conceptual understanding of the respondents before and after the exposure to innovative assessment techniques, feedback, and interaction.

Keywords: Innovative Assessment Technique; Feedback; Interaction; Digital Literacy; Conceptual Understanding; Online Distance Learning Modality

1. Main text

In this modern era of innovation, various areas in the teaching-learning process became advanced through the integration of digital technologies and innovative practices. Specifically, teaching science online and remotely is a challenging endeavor. The most obvious reason for the complexity is dealing with the practical and applied components such as laboratory, fieldwork, and design projects and the skills needed to be developed there.

Research into the educational effectiveness of chemistry practical work has shown that the laboratory offers a unique mode of instruction, assessment, and evaluation. Laboratory work is an integral and important part of the learning process, used to encourage the development of high-order thinking and learning alongside high-order learning and thinking skills such as argumentation and metacognition (Hofstein & Hugerat, 2021).

Moreover, during the pedagogical design, chemistry teachers tend to misrepresent science by providing a scripted procedure to the students and orienting them to favorable outcomes and grades. Thus, it is suggested that rather than sending a typical "cookbook manual" during experiments to the students, conducting an argument-driven inquiry laboratory will be more useful. Teachers can include peer assessment in lab sessions, providing a dynamic learning environment for the students.

About this, the National Science Education Standards cited that Science educators are changing the way they think about good science education, and educational measurement specialists are acknowledging change as well. Recognition of the importance of assessment to contemporary educational reform has catalyzed research, development, and implementation of new methods of data collection along with new ways of judging data quality. These changes in measurement theory and practice are reflected in the assessment standards.

In the teaching-learning process, assessment is the systematic gathering and analyzing of information to inform and improve student learning or programs of student learning considering goal-oriented expectations. The view of students of science influences their performance in class in the same way as for the teachers. Their perception of science and their experiences as students can affect their outputs and performance-based learning tasks. It is then very crucial that those experiences that have shaped the teachers are the same learning experiences that are transferred to their learners. In other words, teachers taught their students, in the manner they were taught by their teachers. Science should not be viewed as an organized body of knowledge that is taught traditionally: giving instructions, following instructions, and pure memorization. Science in the 21st century is different, it is indeed a dynamic and absolutely the key to progress. It is a great challenge for educators to make a difference and contribute to elevating the scientific literacy in our country. Accompanied with these challenges, are the learners of the 21st century, who are more active rather than passive, who need to be developed holistically rather than partially, and who have unique differences rather than similarities.

As stated in DepEd Order No. 31, series of 2020 in the Interim Guidelines for Assessment and Grading considering the Basic Education Learning Continuity Plan, assessment methods are the ways you gather evidence of a learner's progress over time. Teachers should use a range of assessment methods for learners to demonstrate their learning. As you assess you should record evidence of how well each learner has demonstrated each criterion. Research shows that one of the most influential factors in improving learning is for learners to receive clear and specific feedback while they are learning.

Science disciplines such as Chemistry need to develop advanced spatial abilities and visual literacy (Harle and Towns 2011). They need to acquire "hands-on" experience such as performing titrations, synthesizing organic compounds, and analyzing mixtures using advanced instrumentation techniques. The transition of chemistry laboratories to an online mode was not a straightforward endeavor. Thus, the choice of a typical chemistry experiment on a virtual platform became a challenging task for chemistry educators.

1.1. Structure

The study employed a descriptive-developmental research design. This method was the most appropriate since the study dealt with finding the effectiveness of digital literacy and innovative assessment techniques in the instructional delivery of chemistry in an online distance learning modality. The output consists of lessons learned from developing specific products and analyzing the conditions that facilitate their use (Klein, 2005). In this study, innovative assessment techniques were designed and integrated into learning materials under the online distance learning modality while developing the students' digital literacy skills.

The study's design had various development procedures, including the evaluation of output, which, in this study, refers to the innovative assessment techniques and digital literacy skills of the students. This study compared the difference between pre-and post-test scores in assessing the students' conceptual understanding of Chemistry. Upon pretest and posttest administration among the respondents, the test results were gathered at the end. From the difference in the results, a conclusion was drawn.

The instruments that were utilized to obtain the needed data were a questionnaire for digital literacy skills and a researcher-made test to measure the performance of learners before and after the experiment. The researcher-made test consisted of thirty-five (35) items. In preparing the test, the researcher identified the topics first and prepared a table of specifications. The draft of the test was then constructed.

After the test construction, the preliminary draft was given to the researcher's adviser and other Science teachers for content validation. The external validators' suggestions and comments were incorporated into the revision of the test. The items that need revisions were modified.

The trial run was administered to twenty (20) Grade 9 students at San Pedro National High School, who have been participants in the study, they were chosen because they had taken the subject from their previous year. After the first trial, the test questions were checked, and the test underwent item- analysis. The researcher used the U-L index method of item analysis; was computed the higher and the lower 33% of the students who took the test. The difficulty and the discrimination index of each item were determined and from the result decision on whether to retain or discard an item was based on two ranges. Items with difficulty indices within 21% to 80% and discrimination indexes within 0.21-0.40 were retained.

This study utilized a pretest-posttest descriptive-developmental design to determine the effectiveness of digital literacy and innovative assessment techniques in the instructional delivery of chemistry in an online distance learning modality.

1.2. Tables

In this section, the availability of devices and the accessibility to digital platforms is stated. The digital literacy level of the students is also presented in terms of accessibility, flexibility, and creativity.

Table 1. Availability of Technology Resources as to Digital Tool

DIGITAL TOOL	N	PERCENT
Laptop	17	42.5 %
Desktop Computer	17	42.5 %
Android phone/smartphone	35	87.5 %
iPad/tablet	33	82.5 %
Television	24	60.0 %
Smartwatch	4	10.0 %
Radio	6	15.0 %
Digital camera	5	12.5 %
Storage devices	11	27.5 %

Dichotomy group tabulated at value 1. (N = 40)

Table 1 shows the availability of digital tools among the respondents. It reveals that the majority of respondents have android and smartphones, 87.5 % which is 35 of the total population. On the other hand, only a few have peripheral devices such as a smartwatch, radio, and digital camera. In addition, others have laptops and desktop computers which is both 42.5 % or 17 among the 40 respondents. This suggests that the majority of the respondents have digital tools available at home which are android phones, iPad/tablets, and television.

Table 2. Availability of Technology Resources as to Digital Platforms

DIGITAL PLATFORM	N	PERCENT
Microsoft Word	33	82.5 %
Excel/Spreadsheet	16	40.0 %
MS PowerPoint	31	77.5 %
Google Slide	31	77.5 %

Canva Presentation	26	65.0 %
Padlet Dashboard	25	62.5 %
Mentimeter	24	60.0 %
Slido Application	20	50.0 %
Google Form	34	85.0 %
Google Drive	25	62.5 %
Google Meet	34	85.0 %
Zoom	17	42.5 %
MS Teams	12	30.0 %
Social Media Platforms	36	90.0 %

Dichotomy group tabulated at value 1. (N = 40)

In terms of accessibility to different applications and online platforms, the table shows that the respondents were most familiar with the use of social media platforms with a percentage of 90 %. It is evident also that the subjects were well versed in the use of Google and Microsoft applications such as Google Form, and Google Meet which are both 85 %, 34 among the 40 respondents, and 82.5 % in the use of Microsoft word documents. It proves that the learners were familiar with the utilization of the Google Meet Video Conferencing platform since it is the virtual environment they use in synchronous classes while Google Form is the digital platform they used in assessments. It is noteworthy to observe that the respondents had an ease of access to those applications that need creativity such as MS PowerPoint and Google Slide which are both 77.5 %, and Canva presentation which is 65 %.

Table 3. Digital Literacy as to Accessibility

COMPONENTS	MEAN	SD	VI
Navigates Word Document, PowerPoint, and Excel offices.	3.45	0.75	HL
Uses the computer for learning purposes.	3.43	0.81	HL
Makes social networking services a tool for learning networks.	3.33	0.83	HL
Operates a 'search' command to locate a file.	3.28	0.88	HL
Downloads and uses applications on digital devices.	3.66	0.57	HL
ACCESSIBILITY	3.43	0.77	HL

Legend:

3.26 - 4.00 High Literacy (HL)

2.51 - 3.25 Moderate Literacy (ML)

1.76 - 2.50 Basic Literacy (BL)

1.00 - 1.75 Developing Literacy (DL)

Table 3 presents the data on respondents' accessibility to digital tools and resources, navigating and accessing technological tools and applications. All of the components under accessibility to digital literacy are verbally interpreted as high literacy. The overall mean of 3.43 and standard deviation of 0.77 indicate that the respondents were able to access, manipulate, and navigate digital tools and applications.

The Grade 8 students are enrolled in an online distance learning modality. Most of them were oriented and underwent workshops and training on the use of online platforms. They are being taught using Google Meet and Google Classroom as their virtual classroom environment. The teachers prior to the start of the school year 2021 – 2022 oriented, and trained the students on the guidelines, netiquettes, and recommendations of the technological tools and resources needed in distance learning. The program was a webinar on the orientation and training of both teachers, parents, and learners in terms of the utilization of online distance learning platforms and applications who attended in their respective google meet links. Each class is facilitated by the classroom adviser. The assigned faculty ODL speaker oriented them on ODL procedures and tools to establish and accomplish.

Moreover, each student under the ODL modality received a tablet provided by the local government unit with installed open educational resources and available applications.

Table 4. Digital Literacy as to Flexibility

COMPONENTS	MEAN	SD	VI
Understands the basic functions of computer hardware components	3.40	0.59	HL
Utilizes keyboard shortcuts when accomplishing computer-aided tasks.	3.35	0.74	ML
Finds it easy to learn something by reading it on the computer screen.	3.35	0.80	HL
Manipulates the computer to minimize, maximize, and move windows on the screen.	3.30	0.72	HL
Saves files using a USB drive and google drive at the same time.	3.28	0.88	HL
FLEXIBILITY	3.34	0.75	HL

Legend:

3.26 - 4.00 High Literacy (HL)

2.51 - 3.25 Moderate Literacy (ML)

1.76 - 2.50 Basic Literacy (BL)

1.00 - 1.75 Developing Literacy (DL)

The table shows the overall components of digital literacy as to flexibility in understanding, utilizing, and manipulating digital tools and platforms are verbally interpreted as high literacy.

Clear understanding and equipped personnel and learners of ODL Modality transpired in the process. Both teachers and learners were flexible with the use of digital devices, such as laptops, tablets, smartphones, and desktop computers, with available online resources and internet connectivity. The learning resources available are, but not limited to, the following: SLMs for Alternative Delivery Modes (ADM), teacher-made videos and supplementary materials, and open educational resources (OERs). SLMs and primer lessons were converted into different digital forms such as interactive lessons or electronic books (e-books) or google form and were available through the DepEd Learning Resources Portal, DepEd Commons, and/or different DepEd recognized learning management systems.

Table 5. Digital Literacy as to Creativity

COMPONENTS	MEAN	SD	VI
Shows interest in studying and doing activities using computers.	3.60	0.55	HL
Makes use of mobile applications for language learning purposes.	3.50	0.82	HL
Records and edits digital sounds.	3.30	0.94	HL
Takes and edits digital photos.	3.50	0.78	HL
Design slide decks in PowerPoint, Canva, or Google Slides.	3.63	0.67	HL
CREATIVITY	3.51	0.75	HL

Legend:

3.26 - 4.00 High Literacy (HL)

2.51 - 3.25 Moderate Literacy (ML)

1.76 - 2.50 Basic Literacy (BL)

1.00 - 1.75 Developing Literacy (DL)

The table reveals that all of the respondents showed creativity in the use of different applications and digital tools. This is true that the overall components under creativity in digital literacy had a weighted mean of 3.51 and a standard deviation of 0.75, which is verbally interpreted as high literacy. It shows that the respondents were creative in terms of presentation, and digital arts whether computer-aided technologies or mobile applications.

A highly positive component of digital literacy that the respondents exhibit in utilizing digital tools and resources. Students were found to have a high level of digital creativity. Students were able to manipulate and create their outputs, performance tasks, and presentations in a creative manner. The online platform through webinars of training allowed the facilitators and the teachers to share their expertise about the tools, and applications while the participants listened, performed, and worked at their own pace making themselves both available in the processing of activity to share thoughts and clarify queries.

The performance of the two groups echoes their achievements in the researcher-made test conducted before and after the experiment. The comparison of the pretest results and the posttest results between the two groups were sought to establish the effect of using the innovative assessment teaching in the instructional delivery of Chemistry teaching. The succeeding tables present the analysis of these sought differences.

Table 6 shows the pre-performance scores, mean scores, and standard deviation with the corresponding verbal interpretation.

Table 6. Pre-performance scores of the two groups of students as to their conceptual understanding

Conceptual Understanding	**Feedback Technique**	**Innovative**	**Assessment**	**Interaction Technique**	**Innovative**	**Assessment**
	MEAN	SD	VI	MEAN	SD	VI
Factual Recall	74.50	12.34	D	73.50	9.33	D
Inference	77.50	9.10	B	76.50	8.13	B
Observation	70.00	9.73	D	71.50	8.75	D
Formulating Hypothesis	71.00	10.21	D	71.50	7.45	D
Testing Hypothesis	73.50	11.37	D	73.50	7.45	D
Analyzing Data	70.00	10.26	D	72.50	9.67	D
Drawing Conclusion	70.00	9.18	D	71.00	9.12	D
Overall Mean	72.36	9.18	D	72.86	8.56	D

Legend:

90 % – 100 %	Advanced (A)
85 % – 89 %	Proficient (P)
80 % - 84 %	Approaching Proficiency (AP)
75 % - 79 %	Beginning (B)
74 % and below	Developing (D)

The test aimed to measure the effectiveness of the innovative assessment techniques. It can be gleaned from the table that the majority of the respondents achieved a developing performance in their pretest overall mean scores. However, it can be noted that in inference, a mean score of 77.50 under feedback and 76.50 under interaction innovative assessment techniques reveal that the respondents were beginning at inferential conceptual understanding.

The two groups of students during their pre-performance assessment are both on the developing level suggesting that the respondents need development and improvement in the following topics: introduction to atoms and the periodic table of elements. Students have little prior knowledge of the topics in items 26-35, a developing understanding which fell under analyzing data and drawing conclusions since it's the first time it was taught. On the other hand, items 6-10 reveal that the students have a beginning understanding of the lesson which fell under inference conceptual understanding.

The analysis of the difference in the performance of the respondents after the exposure to innovative assessment techniques was shown in table 7.

Table 7. Post-performance scores of the two groups of students as to their conceptual understanding

Conceptual Understanding	**Feedback Technique**	**Innovative**	**Assessment**	**Interaction Technique**	**Innovative**	**Assessment**
	MEAN	SD	VI	MEAN	SD	VI
Factual Recall	92.00	6.16	A	92.50	8.51	A
Inference	90.00	8.58	A	91.00	7.18	A
Observation	81.50	11.37	AP	85.50	8.26	P
Formulating Hypothesis	80.50	7.59	AP	83.50	7.45	AP
Testing Hypothesis	79.50	10.50	AP	81.50	6.71	AP
Analyzing Data	75.00	10.99	B	79.50	9.99	AP
Drawing Conclusion	82.50	10.20	AP	84.50	8.87	P
Overall Mean	83.00	9.34	AP	85.43	8.14	P

Legend:

90 % – 100 % Advanced (A)

85 % – 89 % Proficient (P)

80 % - 84 % Approaching Proficiency (AP)

75 % - 79 % Beginning (B)

74 % and below Developing (D)

Exposure to innovative assessment techniques plus the utilization of digital tools reveals the improvement in the conceptual understanding of the respondents. The overall mean score of 83.00 with a standard deviation of 9.34 reveals that the conceptual understanding of the learners who were employed to feedback on innovative assessment technique is approaching proficiency. On other hand, an 85.43 proficient level of understanding is gleaned from students who were exposed to interaction innovative assessment technique. Meanwhile, improvement in analyzing data with a mean score of 75 and a standard deviation of 10.99 needs to be stressed to develop the conceptual understanding of the learners. Students' responses exposed to feedback innovative assessment technique needs to focus on analyzing data to improve their conceptual understanding and response logically and analytically. This can be gleaned in items nos. 26-30. There is a necessity for progress in terms of analyzing contents and topics in conceptual reasoning in Chemistry instructions.

Under feedback innovative assessment technique, the students worked on their outputs, projects, and written tasks which shows an understanding of the concepts. Competencies of the topics were discussed by the learners in their responses to queries and answered in their summative examination. Using online platforms and applications, the lessons were discussed, and students gave their responses as feedback on their written and performance tasks. The creative presentations, and answered supporting questions were submitted, and turned-in outputs. The students were interested to learn.

The same is true for the interaction innovative assessment technique where students discussed the lessons in pairs and clusters. Peer-to-peer interactions via online groupings were apparent and outputs were turned-in as group work. The teacher as facilitator gave instructions using online platforms like Mentimeter, and Padlet application where students responded with creative and innovative answers.

The posttest reveals that employing innovative assessment techniques improve the conceptual understanding of the respondents. The significance that this finding reveals that the developing conceptual understanding of the respondents in their pretest scores served as additional proof that using feedback and interaction innovative assessment techniques in the instructional delivery of Chemistry improves the performance of the students. All of the conceptual understanding components show improvement in their performance scores.

The analysis of the differences in the performance of the respondents after the experiment was shown in tables 8 and 9. Results of the pretest and posttest for both the control and experimental groups were subjected to a t-test to reveal if a significant difference will exist.

Table 8. The significant difference between the means scores of the respondents under the Feedback Innovative Assessment Technique

Conceptual Understanding	**Posttest**		**Pretest**				
					t	**df**	**Sig. (2-tailed)**
	M	SD	M	SD			
Factual Recall	92.00	6.16	74.50	12.34	6.72	19	.000
Inference	90.00	8.58	77.50	9.10	5.78	19	.000

Observation	81.50	11.37	70.00	9.73	4.20	19	.000
Formulating Hypothesis	80.50	7.59	71.00	10.21	4.05	19	.001
Testing Hypothesis	79.50	10.50	73.50	11.37	2.26	19	.036
Analyzing Data	75.00	10.99	70.00	10.26	2.77	19	.012
Drawing Conclusion	82.50	10.20	70.00	9.18	4.80	19	.000
Overall Mean	83.00	9.34	72.36	10.31			

It can be gleaned in table 8 the significant difference between the pretest and posttest of the respondents who were employed with feedback innovative assessment technique. The findings and improvements from developing to approaching proficiency based on observation, analyzing data, and drawing conclusions were shown from a mean score of 70.00 to 75.00, 81.50, and 82.50 respectively. A t-test of 6.72 under factual recall proved the significance of feedback in terms of learners' outputs and performances. This finding made the researcher reject the null hypothesis and conclude that there is a significant difference between the performances of the group after the exposure to the feedback assessment technique. After the students utilized the assessment tool, it helped them to enhance their conceptual understanding through their Chemistry outputs and performance tasks in an online distance learning modality. The lessons in the introduction to atoms and the historical discovery of the periodic table of elements were discussed and assessed via responses in their feedback performance tasks..

This finding can be due to the fact that in general there is a significant change that occurred in the development of the students' conceptual understanding of Chemistry under the online distance learning modality. The performance of the students echoes their achievements in the researcher-made test conducted before and after the exposure to innovative assessment techniques with the aid of digital tools and resources.

Table 9. The significant difference between the means scores of the respondents under the Interaction Innovative Assessment Technique

Conceptual Understanding	**Posttest**		**Pretest**				
					t	**df**	**Sig. (2-tailed)**
	M	SD	M	SD			
Factual Recall	92.50	8.51	73.50	9.33	7.02	19	.000
Inference	91.00	7.18	76.50	8.13	6.18	19	.000

Observation	85.50	8.26	71.50	8.75	5.98	19	.000
Formulating Hypothesis	83.50	7.45	71.50	7.45	6.99	19	.000
Testing Hypothesis	81.50	6.71	73.50	7.45	4.29	19	.000
Analyzing Data	79.50	9.99	72.50	9.67	2.15	19	.045
Drawing Conclusion	84.50	8.87	71.00	9.12	4.93	19	.000
Overall Mean	85.43	8.14	72.86	8.56			

The table reveals that there is a significant difference in the conceptual understanding of the group before and after the exposure to interaction innovative assessment technique. By conventional criteria, this difference is considered to be statistically significant. Peer-to-peer and peer-to-facilitator interaction improve the understanding of the respondents in all components, especially in factual recall with a t-test value of 7.02 under a 95 % confidence interval of this difference. This finding made the researcher reject the null hypothesis and conclude that there is a significant difference in the conceptual understanding of the group after the experiment.

The students who were exposed to interaction innovative assessment technique showed improvement in their conceptual understanding. From developing to approaching proficiency up to the advanced level of understanding. Students were excited to do their activities with their partners or with their groups. Everyone was given an opportunity to explore, lead, and create their outputs. Collaboration as a group became the key to learning together where Chemistry is a subject that has the power to engage and enthuse students but also to mystify and confound them. Effective chemistry teaching requires a strong foundation of subject knowledge and the ability to transform this into teachable content which is meant for students.

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