Asia Pacific Journal of Advanced Education and Technology
Special Issue, September 2022 / P- ISSN 2815 – 245X / E – ISSN 2815 – 2468 / www.apjaet.com

Technology- Based Formative Assessment and Learning Outcomes in Science among Grade 10 Students in an Online Instructional Delivery Program

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DOI: https://doi.org/10.54476/apjaet/80033

Abstract

This study introduced the elements of technology-based formative assessment and assessed its effect on the learning outcomes of the students. Descriptive correlational research design-led in attaining the study's objectives to determine the relationship of technology-based formative assessments and learning outcomes in science among 58 grade 10 students in an online instructional delivery program. Utilizing a researcher-made survey questionnaire, it intended to measure whether the perception of the elements of technology-based formative assessments affects students' problem-solving skills and the student's active engagement in an online learning set- up. The findings showed that the elements of technology-based formative assessment in terms of classroom culture, learning goals, methodologies, assessment qualities, and feedback is not significantly related to the problem-solving skills of the students. Moreover, the result implies that the elements of technology-based formative assessment are not the determining factors to improve the problem–solving skills of the students. On the other hand, the elements of technology-based formative assessment in terms of classroom culture, learning goals, methodologies, assessment qualities, and feedback has a significant relationship with student's active engagement as to learner to learner, learner-to-teacher, and learner-to-content which increased student's active engagement in an online learning set- up. Moreover, in the level of active engagement of the students, the more that the technology-based formative assessment is utilized the more that they are actively engaged in an online learning set-up.

Keywords: technology-based formative assessment, problem-solving skills, learning outcomes, active engagement

Introduction

COVID-19 brought us all into this situation where all of us need to enhance the way we acquire knowledge, especially in education. As stated in the study of AlMahdawi, Senghore, Ambrin, & Belbase (2021). A synchronous online mode that replaces the conventional face-to-face classroom only needs a basic understanding of technology. Consequently, Ong (2021) stated that students' learning experiences are being changed. Teachers, students, parents of the learners, and even the community are helping each other to cope with this situation. To cater to the needs of the students, The Department of Education's

Basic Education Learning Continuity Plan (BE-LCP) provides a set of interventions to address the basic education challenges brought on by COVID-19 as stated in the DepEd order no. 007 series of 2020.

Palo Alto Integrated School (PAIS) conducted a survey on the preferred modality of the students as part of the Enhanced BE-LCP implementation for SY 2021-2022. Results showed that of 574 enrolled grade 10 students, only 58 learners chose online modality, which reflected on the availability of the resources such as internet connection and devices needed in online classes.

According to Biundo & Wendemuth (2017), the way that students and teachers use technological tools, such as computers and other hardware, as well as online web-based tools, such as learning management systems, applications, and various learning and teaching tools, has an impact on online and distance learning. Ong (2021) added that increasing the learning process requires the use of formative assessment.

Serafica (2018) cited that Science education offers the knowledge and skills that are essential for one to survive, assisting students in learning significant ideas and facts that are relevant to day-to-day activities.

Even before the Covid 19 pandemic struck, weaknesses in this area manifested in Several standardized tests, including the National Achievement Test, show poor performance from Philippine high school students (NAT). In the National Achievement Test for the school year 2017-2018, Subject Areas with the 21st Century Skills, specifically Problem-Solving was measured. The DepEd reports that in the result of NAT for high school, among the three 21st Century Skills Problem Solving recorded low in terms of the mean percentage score (MPS) of 47.48 which implies low performance. In terms of the mean performance of the learners by subject area, Science got the mean percentage score of 36.52 which implies low proficiency level.

In the 2018 cycle of the Programme for International Student Assessment (PISA), where DepEd participated, in comparison to the OECD average of 489 points, Filipino students scored an average of just 357 points and indicate level 1a category in the learner's performance in Science among Filipino learners OECD PISA (2018).

However, the results of Grade 10 students of PAIS in 2019-2020 examinations had MPS of 55.75%. This showed that the score is beyond the national 75% as the mean percentage score and implied low performance among grade 10 learners of Palo Alto Integrated School (PAIS).

This accounts to investigate the perception of the students on the elements of Technology- based formative assessment, especially in online distance learning modality. Besides looking into how the students perceive the elements of Technology- based formative assessment they are given to make remediation in their cognitive aspects given the fact that there is low proficiency in the three 21st century skills specifically problem-solving skills as reported by DepEd in the result of NAT Test for the school year 2017-2018.

So, this study aims to determine the relationship between the perception on Technology- based formative assessments and learning outcomes in science among grade 10 students in an online instructional delivery program.

Objectives of the Study

The aim of this study is to determine whether relationships exist between the use of Technology- based formative assessment and learning outcomes in science among grade 10 students in an online instructional delivery program in Palo Alto Integrated School within the school year 2021- 2022.

Specifically, 1) the respondent's perception on classroom culture, learning goals, methodologies, assessment qualities, and feedback as elements of Technology- based Formative Assessment (TBFA), 2)

the level of learning outcomes as to problem-solving and active engagement and 3) whether the elements of TBFA relate significantly to the learning outcomes.

Methodology

This study is descriptive correlational research design-led in attaining the study's objectives to determine the relationship between technology-based formative assessments and learning outcomes in science which involved 58 grade 10 students who are enrolled in Palo Alto Integrated School for School Year 2021 – 2022 and are under the ODL program. Utilizing a researcher-made survey questionnaire in gathering relevant information from the respondents. The questionnaire was submitted to experts for content validation and the test of reliability.

The mean and standard deviation of the respondent's perception of the elements of Technology- based formative assessment and level of Problem- Solving skills were computed. Pearson Product Moment Correlation Coefficient was used to find out the significant relationship between the respondents' perceived elements on the Technology- based formative Assessments and learning outcomes in science among Grade 10 students in an online instructional delivery program.

Results and Discussion

1. Perception of the elements of technology-based formative assessment

1.1. In terms of Classroom Culture

Table 1
Respondents' perception of the elements of technology-based formative assessment in terms of classroom culture

Indicators	Mean	SD	Interpretation
power distance	3.20	0.42	Exhibited
uncertainty avoidance	3.22	0.43	Exhibited
collectivism	3.06	0.48	Exhibited

In integrating technology-based formative assessment, students are included in every task and comfortable to share how they feel in every response. It also challenged their idea whenever they ask questions based on the instructions using technology-based formative assessment. Using technology-based formative assessment, students are engaged in the assessment process when there is an interaction between their classmates and teachers.

According to Hofstede as cited by Bardakci, et al. (2018), In an online classroom with a power distance culture, students only participate when the teachers invite them to or when they anticipate that the teachers will start the conversation. This implies that due to a high index of power distance, interactions between students and teachers, especially those that take place online, tend to follow certain cultural patterns. Students understand well the lesson when there is a structured objective and when the criteria are presented in an easy-to-understand process as well as when there is a detailed step on how to perform certain tasks especially when technology-based formative assessment is being utilized.

There are many benefits to high levels of uncertainty avoidance in the learning environment; students are more at ease when assignments are prospected in detail and objectives are clearly stated as cited in the study of Bardakci, et. al. (2018).

As stated by Bardakci, et. al. (2018), students under collectivism usually answer the task when the teacher encourages them to do it. Without teacher presence and initiative, students will not participate in the class discussion.

1.2. In terms of Learning Goals

Table 2
Respondents' perception of the elements of technology-based formative assessment in terms of Learning Goals

Indicators	Mean	SD	Interpretation
competence	3.26	0.46	Exhibited
autonomy	3.18	0.49	Exhibited
interest	3.21	0.45	Exhibited
relatedness	3.12	0.54	Exhibited

In integrating technology-based formative assessment, students can be able to apply the new skills that they have learned in different contexts by relating the lesson to the learning goals and students can identify possible misconceptions to help them in completing the assessment or task.

According to Usher & Kober (2012), students participate in an online discussion and engaged themselves in an assessment because they believed that they could acquire the learning goal intended for them to master the content. Using appropriate student choices and a suitable assessment tool, teachers can concentrate on developing responsible and independent learners. Giving students the freedom to select topics that interest them encourages their innate curiosity and desire to learn.

According to Usher & Kober (2012), In terms of students' interest, students completed the task when they are interested in the way teachers give or presented it, especially when the teacher utilized different methods or varied tools in presenting the lesson as well as giving a technology-based formative assessment. Thus, students see the value of completing the task.

1.3. In terms of Methodologies

Table 3
Respondents' perception of the elements of technology-based formative assessment in terms of Methodologies

Indicators	*Mean*	*SD*	*Interpretation*
online quizzes	3.26	0.50	Exhibited
open – ended questions	3.20	0.45	Exhibited
drag and drop activities	3.18	0.46	Exhibited
online polls	3.27	0.50	Exhibited
game type activities	3.14	0.51	Exhibited

This implies that students are engaged in online assessment especially when the teachers use Technology- based formative assessment which enhances their understanding through different online features in online quizzes.

According to Looney (2010), teachers can elicit additional information about student learning, apply new abilities in diverse contexts and use various media like online quizzes.

In addition, students are engaged in developing their problem-solving skills using an open-ended type of assessment using technology-based formative assessment. When the teacher gives more elicit questions to the students, they are encouraged and challenge to answer the question by applying problem-solving skills.

According to Looney (2010), through open-ended activities for learning assessment, students can bring a variety of experiences, perceptions, and ways of communicating and processing ideas into the classroom. As a result, teachers employ a diverse set of strategies to assist students in achieving their learning objectives.

Teachers who use online polls in teaching students can quickly assess students' learning. Teachers can easily assess students feeling and understanding about the lesson using this kind of activity that allows students to choose based on their point of view. Students are also engaged in decision-making.

Game-type activities as integrated through technology-based formative assessment engaged student and makes them participate well in the class discussion especially when the assessment process in interactive and involved the whole class in the activity.

1.4. In terms of Assessment

Table 4
Respondents' perception on the elements of technology-based formative assessment in terms of Assessment

Indicators	*Mean*	*SD*	*Interpretation*
incremental	3.20	0.47	Exhibited
interactive	3.19	0.51	Exhibited

Incremental Assessments focus on assessing current understanding through the use technology-based formative assessment in online learning set-up. Formative assessment can be incremental to engage students to participate in the online discussion. In the online learning set-up, incremental assessment is one of the sub-elements of the assessment process in Technology- based formative assessment that pertains to the step-by-step process of giving/ administering assessment as stated by Looney (2010).

In the study conducted by Ghysels & Haelermans (2014) on the effects of an individualized, a fun, interactive online practice tool for 7th graders' fundamental math abilities. The results suggested that practicing math skills with the interactive tool results in a sizable improvement in math proficiency.

1.5. In terms of Feedback

Table 5
Respondents' perception on the elements of technology- based formative assessment in terms of Feedback

Indicators	*Mean*	*SD*	*Interpretation*
timeliness	3.19	0.45	Exhibited
constructiveness	3.13	0.50	Exhibited
meaningfulness	3.18	0.49	Exhibited

Timely feedback that is provided gave students enough thinking time to improve their performances and allowed students to focus on the task at hand. Students also used feedback provided by the teacher to change and improved their work.

Technology was used to personalize feedback, which encouraged learning as cited by Ai (2017). According to Spector, et al. (2016), Technology can be used by teachers to assess students' performance, monitor their development, and adapt their instruction to each student's needs.

Constructive feedback can help students perform the task better. Constructive feedback should also start with a positive feature to encourage the students and uplift their confidence in doing the task. But also, constructive feedback can be negative, but the interpretation of the students and teachers should be in positive way which encourages the students to perform better and avoid the mistakes that they have encountered in completing the tasks.

Students when given meaningful feedback about their work tend to think and process it to improve their performances. Meaningful feedback also assessed students' current understanding of the task performed.

2. Level of Performance of the Respondents in terms of their Problem-Solving Skills and Active Engagement

2.1. In terms of their Problem-Solving Skills

Table 6
Level of Problem-solving Skills of the respondents

Indicators	Mean	SD	Level
Defining the problem	2.54	0.50	Advanced
Generating new ideas	2.47	0.54	Proficient
Evaluating and selecting solutions	2.44	0.58	Proficient
Implementing the solution	2.35	0.70	Proficient

It can be gleaned that in the level of learning outcomes as to problem-solving skills, defining the problem received the highest mean. This means that most of the students are advanced levels of the problem- solving skills. Most students can be able to answer the problem presented. They can also give concrete and logical solutions to the problem that can be applied in real-life situations. This can be observed in the task given to the students in an online learning set- up.

The level of learning outcomes as to problem-solving skills, generating new ideas, evaluating, and selecting solutions, and implementing the solution showed that the students in a proficient level. This implies that most students' ability in solving the problem is evident. When students are provided with scenarios or problems that can be encountered in the community, they can be able to evaluate and assess the problem and then give a reasonable solution to the problem encountered.

As cited in the study conducted by Hidayani, et. al. (2020), skills in solving a problem can be developed through science subjects which give logical and scientific problems that improve problem-solving skills.

2.2. Active Engagement

Table 7
Level of Active Engagement of the respondents

Indicators	Mean	SD	Level
Learner to Learner	**3.03**	**0.60**	Exhibited
Learner to Teacher	**3.17**	**0.51**	Exhibited
Learner to Content	**3.18**	**0.46**	Exhibited

Students' interaction with each other promotes positive feedback that enables them to perform the tasks better. Through the integration of technology, students can work collaboratively using online communication tools to accomplish the assessment or task given.

Interaction between students fosters student engagement, which is vital for online learning. These activities promote a strong sense of community among the students and help them feel connected. It improves student-to-student interaction by using videoconferencing or chat during synchronous activities, and discussion boards during asynchronous ones as suggested by Banna, et. al. (2015).

Interaction between students and teachers boosts student engagement in online classes as cited in the study by Martin & Bolliger (2018).

It also implies that the level of active engagement of students to content or subject matter is exhibited in an online learning set- up which means that by using technology-based formative assessment through utilizing different formats like text, video, audio, interactive games, or simulations students can easily understand the lesson and the assessment process. Students can be able to work on realistic scenarios to apply what they have learned especially when they are expressing their ideas in an online discussion.

Students are also engaged in the learning contents when they experience live, synchronous web conferencing for class discussion of the lesson especially when my teacher administers online assessment which promotes an interactive way of communication with the teacher.

3. Test of the relationship between the perceived elements of Technology- Enhanced Formative Assessment and the Learning Outcomes of the respondents

Table 8
Relationship between the perceived elements of Technology- based formative Assessment and the Learning Outcomes of the respondents

Elements of TEFA	Learning Outcomes						
	Problem – Solving Skills				Active Engagement		
	Defining the Problem	Generating New Ideas	Evaluating and Selecting Solutions	Implementing the Solution	Learner to Learner	Learner to Teacher	Learner to Content
Classroom Culture	0.086	0.105	0.026	0.079	0.427**	0.557**	0.640**
Learning Goals	-0.094	-0.048	-0.113	-0.078	0.494**	0.628**	0.759**
Methodologies	-.0.024	0.029	-0.040	-0.027	0.508**	0.737**	0.841**
Assessment Quality	-0.033	0.031	-0.054	-0.035	0.478**	0.727**	0.826**
Feedback	0.014	0.044	0.011	0.011	0.515**	0.687**	0.738**

Based on the elements of Technology- based formative assessment in terms of classroom culture, learning goals, methodologies, assessment qualities, and feedback have no significant relationship with the problem-solving skills of the students. It implies that classroom culture does not have a significant relationship to the problem- solving skills.

As to the learning goals and problem-solving skills, it shows that defining the problem (-0.094), generating new ideas (-0.048), evaluating, and Selecting solutions (-0.113), and implementing the solution (-0.078) get the negative values. It means that when the students' goal or wants to acquire the use of technology-based formative assessment have been exhibited in online learning set-up, but their problem-solving skills do not affect the skills to be improved using a technology-based formative assessment that is utilized in online learning set up.

Results showed that there is no significant relationship between the methodologies and problem-solving skills which give negative values in terms of defining the problem (-0.024), evaluating, and selecting solutions (-0.040), and implementing the solution (-0.027). It means that methodologies have been exhibited when utilizing technology-based formative assessment in an online learning set- up but do not relate to the student's problem-solving skills due to overwhelming strategies and varied methods used by the teacher to deepen learning and meet the diverse needs of students.

On the other hand, when it comes to generating new ideas, it gives a positive value of 0.029. It only means that the method used by the teacher that integrates technology-based formative assessment allows students to create and think of relevant ways that are needed to undertake for the problem to be solved but still not significantly related to the problem-solving skills of the students.

As to the relationship between Assessment quality and problem-solving skills, there is no significant relationship between the variables which gives negative values as to defining the problem (-0.33), evaluating, and selecting solutions (-0.054), and implementing the solution (-0.035). It means that incremental and interactive assessments have been exhibited when integrating technology-based formative assessment in an online learning set- up but do not have a significant effect in improving the problem-solving- skills of the students. On the other hand, in terms of assessment qualities and problem-solving skills, as to generate new ideas, results showed that there is a positive value of 0.031 but still do not have a significant relationship with each other. It means that when the technology-based formative assessment is incremental and interactive it can increase students' creativity and engagement in an online learning set- up but does not improve problem-solving skills.

The elements of technology-based formative assessment in terms of feedback and problem-solving skills have not significantly related to one another but give a positive value in defining the problem (0.014), generating new ideas (0.044), evaluating, and selecting solutions (0.011), and implementing the solution (0.011) which means that when the teacher gives timely, constructive, and meaningful feedback to the student's performance when technology-based formative assessment is being utilized. The feedback that is timely, constructive, and meaningful is exhibited and integrated into the online learning set- up but does not affect the skills to solve problems.

On the other hand, it can be gleaned that the elements of technology-based formative assessment is significantly related to students' active engagement in terms of learner-to-learner, learner-to-teacher, and learner-to-content engagement. It can be implied that technology-based formative assessment can be related to the active engagement of students in online learning set- up.

It means that the more the technology-based formative assessment is used the higher the engagement of the students which is evident in online learning setup.

Results showed that there is a significant relationship when it comes to classroom culture and student active engagement as to learner to learner (0.427), learner to the teacher (0.557), and learner to content (0.640) which means that there is a significant impact on the use of technology-based formative assessment on the increased level of student's engagement in the teaching-learning process in an online learning set-up.

On the degree of correlation between classroom culture and active engagement, learner-to-content gives the highest value of association which means that it has been found that active learning techniques are a successful way to involve students and enhance their academic performance as cited in the study of Martin & Bolliger (2018).

There is a significant relationship between learning goals and student's active engagement as to learner to learner (0.494), learner-to-teacher (0.628), and learner-to-content (0.759) which means that the students exhibited their learning goals that utilized the use of technology-based formative assessment that increased active engagement which makes the students participate actively in an online class discussion especially when the teacher uses technology-based formative assessment. Learner-to-content gives the highest value on the degree of correlation.

Methodologies have a significant relationship with the learning outcomes of the students as to active engagement as to learner to learner (0.508), learner to the teacher (0.737), and learner to content (0.841) which means that the variety of methods used by the teacher promotes a positive relationship with the student's engagement which allows them to interact actively in an online class set up.

On the degree of correlation between methodologies and active engagement, it is learner-to-content that gives the highest association which means that according to Martin & Bolliger (2018), it is necessary to choose the right assessment techniques and activities that allow students to explore, discover, and hone their abilities as well as learn about the lesson's subject matter. There is a significant relationship between incremental and interactive assessment and the student's engagement as to learner to learner (0.478), learner to the teacher (0.727), and learner to content (0.826). On the degree of association between incremental and interactive assessment and the student's engagement, it is learner content that gives the highest value of correlation. It implies that when the teacher utilizes a step-by-step process of the assessment procedures and gives an interactive assessment tool to the students, it can increase the interaction and active participation among students in an online learning setup.

Moreover, there is a significant relationship when it comes to feedback and active engagement of the students as to learner to learner (0.515), learner to the teacher (0.687), and learner to content (0.738) when technology-based formative assessment is being utilized and integrated into an online learning set- up. It means that when the teacher focuses on providing feedback that is precise and given promptly/real-time manner it can increase students' active engagement in the online learning set-up.

On the overall result, it implies that the elements of technology-based formative assessment are not the determining factors to improve the learning outcomes of the students as to problem-solving skills but can increase student's active engagement in an online learning set- up.

Conclusions

In light of the findings, the following conclusions are hereby drawn:

1. The hypothesis stating that there is no significant relationship between the perceived elements of technology-based formative assessment and the learning outcomes as to problem- solving skills of the respondents is sustained. Moreover, the result implies that the elements of technology-based formative assessment are not the determining factors to improve the problem-solving skills of the students.
2. While the hypothesis stating that there is no significant relationship between the perceived elements of technology-based formative assessment and the learning outcomes as to the active

engagement of the respondents is not supported. In addition, technology-based formative assessment increased students' active engagement in an online learning set- up.

Recommendations

Based on the findings and conclusions drawn, the following are hereby offered:

1. Since the elements of technology-based formative assessment are exhibited and integrated into the online learning set-up, the more that the technology-based formative assessment is used the higher the students actively engage in an online discussion. Thus, teachers must find ways to improve the utilization of these elements to cater needs of the students and ensure its effectiveness.
2. Teachers may also use the result of the study to explore further beyond traditional instruction, that is, to integrate different technology-based formative assessments in teaching science and other disciplines to increase student's engagement in the lesson.
3. Since technology-based formative assessment and problem-solving skills of the students do not significantly relate, future researchers may look for other skills to enhance students' ability in science to report the level acquired and look for other ways to improve which contribute to the advancement of the educational system in the country.
4. Future researchers may also examine how teachers' and students' perceptions of formative assessment practice align to explore whether or not this alignment indicates a mutual understanding of formative assessment.

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