Collaborative Design of Performance Assessment-Driven Lessons to Explore on Students' Learning Experience in Mathematics

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ABSTRACT

Research has shown how authentic assessment provides an opportunity for a meaningful mode of alternative assessment. However, barriers to its effective utilization remain present in high school math classrooms. Hence, this study addresses the gap in the teachers' ability to implement PA by exploring their collaborative process of designing Performance Assessment-Driven Lessons (PADL) in Mathematics. Moreover, this study aims to examine the impact of PADL on students' learning experiences. Using a descriptive qualitative approach, four in-service teachers participated in the design of PADL, while twenty Grade 9 students engaged in its implementation. Results revealed that the collaborative process of in-service teachers in designing PADL was focused on enriching students' learning experiences and addressing their potential difficulties. The said process followed the stages: 1) identifying learning objectives, 2) determining the scoring rubric to be used in the implementation of PADL, 3) writing the Performance Assessment-Driven Lessons, 4) testing and anticipation of students' potential difficulties, and 5) reflection and revision. Moreover, the implementation of PADL enabled students to explain mathematical concepts, collaborate and consolidate their understanding, ask clarificatory questions, and develop a deeper appreciation for mathematics, thus exhibiting the potential to enrich mathematics learning.

Keywords: Performance Assessment, Collaborative Lesson Design, Mathematics Lessons, Students' Experience

INTRODUCTION

In the past years, reforms in mathematics education have involved a renewed focus on the application of innovative assessment methods to ensure students' improved learning outcomes. Traditional assessment techniques that work on mere memorization have come under criticism for their limited ability to measure what students truly understand about a topic (Fauziah, 2017). With this, authentic methods of assessment were brought to the forefront. Authentic assessment in mathematics is known to improve student performance (e.g. Sambeka et al., 2017; Winarso, 2018) and reveals information about their needs and abilities (Syaifuddin, 2020). Particularly, researchers suggest the use of performance assessment (PA) as a form of authentic assessment as it allows students to apply their knowledge in completing real-world tasks (Reyes-Cedeno et al., 2019).

Unlike the conventional types of tests, PA methods bring the opportunity for deep understanding by making students integrate several concepts into a meaningful real-life context application (Nitko, 2000). When integrated into mathematics instruction, PA can enhance higher-order thinking skills (Popham, 2014), increase student involvement, and stimulate positive attitudes toward learning (Ahrin, 2015). However, despite its known potential, teachers often need help in integrating PA in the classroom due to the lack of experience with the approach, time pressures, and pressures of designing appropriate learning experiences for diverse students (McFeetors, 2021; Fan & Zu, 2008).

Hence, there is an important gap in mathematics education; that is, several benefits of PA have been established, while many teachers are restricted from effective integration in class. With this, professional development programs are still required to support their needs to design and execute an effective PA-driven lesson. In addition, a solution suggested to this problem is the collaborative nature in designing a lesson whereby teachers work together in a reflective process to create performance assessment-based instructional materials (Metin, 2013). Collaborative lesson design tends to advance the quality of curricular materials as well as build teachers' confidence in planning meaningful learning experiences (Borko, 2004; Voogt et al., 2011). To date, little research has been performed documenting how collaborative lesson design undertakes the challenges of the effective crafting and implementation of performance-driven lessons in mathematics.

Therefore, this study explored the collaborative design of incorporating performance assessment in mathematics lessons. More particularly, it sought to address two interrelated research objectives: 1) determine the in-service teachers' collaborative process of designing Performance Assessment-Driven Lessons (PADL) in Mathematics, and 2) investigate the impact of a collaboratively designed PADL on students' learning experience.

Performance Assessment as Authentic Assessment

Performance Assessment (PA) is a type of assessment that requires students to demonstrate that they have mastered specific skills and competencies by performing an activity or solving open-ended problems which apply their understanding of the subject matter (Arhin, 2015). Instead of traditional assessments that have generally been prone to memorization, PA focuses more on the application of knowledge in pragmatic, life-like settings (Darling-Hammond et al., 2008). This is expected to contribute to more productive task completions, stronger relationships between students and teachers, and more insightful problem-solving abilities.

According to Oberg (2010), the PA process allows students to demonstrate their knowledge and capabilities during contexts that reflect real-world situations. Hence, this type of evaluation procedure is really in keeping with authentic learning environments, as tasks are created to resemble skill application during real-life scenarios (Frey, 2014). Likewise, a study by Back and Hwang (2005) supports this assertion and found that performance assessment has a positive effect on the educational values of teaching and learning activities.

As defined within the context of this study, PA is the integration of authentic assessment activities into mathematics lessons in the topic "Variation". These activities, designed by in-service mathematics teachers, allow Grade 9 students to solve open-ended problems that would help the latter apply the knowledge about the topic to practical situations. This is intended to enhance students' learning experience by designing a relevant and engaging mode of assessment.

Collaborative Design Lesson

The value of collaborative design in curriculum materials' development has already been quite well-documented within the realm of mathematics education research (Cobb et al., 2001). Collaboration in designing can facilitate the enhancement of professional development as well as the development of effective curricular materials beneficial to the educational environment (Westbroek, 2019). In efforts of collaboration, teachers design or develop refinement in pedagogical strategies, materials, and methods of assessment toward improving the quality of teaching and learning (Mas'ud, 2019).

Coker et al. (2022) suggest that collaborative designing may be useful in reducing the burdens of writing and implementing challenging lessons. The enactment of the developed curricular materials allows teachers to observe and reflect upon the outcomes. In developing and acting on co-designed curricular resources, teachers have opportunities to see their strategies for teaching and to reflect upon them. A process such as this would promote professional growth but would also positively affect attitudes toward the development of the curriculum by teachers in general (Jong et al., 2021). The collaborative designing aspect of teaching and learning has been proven to enhance teachers' experience and confidence in the preparation of educational materials, thus improving their ability to deliver high-quality learning experiences (Voogt et al., 2011).

METHODOLOGY

The research employed a descriptive qualitative design to investigate the process by which in-service teachers design performance assessments in mathematics classrooms. The general aim was to account for the teachers' collaborative process in designing PADL and to investigate students' experiences of learning with the implementation of PADL.

Participants and Settings

The study was implemented to 20 Grade 9 students from Paquito S. Yu Memorial National High School, Lower Timonan, Dumingag, Zamboanga del Sur, in the second quarter of the 2023-2024 academic year. Four secondary mathematics teachers designed the PADL in collaboration. The teacher and student participants were selected based on purposive sampling to guarantee commitment throughout the study.

Data Collection

Data gathering involved three major sub-aspects: a sequence of collaborative design meetings, the process of implementing PADL, and post-implementation discussion. To carry out this study, the researchers had online meetings with the four participating teachers to collaborate in designing a unit of performance assessment-driven lessons. Each of these meetings was recorded to capture the process and discussions the teachers had about integrating performance assessment into mathematics instruction. The PADL was then introduced in the classroom of one of the participating teacher-collaborators (T_1). The researchers observed the students and paid attention to their reactions, interactions, and communication patterns during the two-week implementation. In addition, the students were grouped into seven permanent groups and each group was distributed with a recording device to record their conversations while attending to the performance tasks. In addition, the students answered writing prompts to help document their thinking processes. After the intervention had been implemented, a focus group discussion was conducted with the students to ascertain how it affected their mathematics learning experience.

Data and Analysis

Various data sources were analyzed to gain a deeper understanding of the teachers' collaborative process in designing the PADL and the student's learning experiences during the implementation. The data from the online meetings involved transcripts that captured the discussion of the teachers and were examined through narrative analysis to provide an interpretation of the core narratives and themes relating to the process of how performance assessment was incorporated into mathematics lessons (Wright, 2015).

Furthermore, the themes related to students' learning experience from the implementation of PADL were derived from multi-source aspects, including the observation of a teacher and researchers, voice recordings, students' artefacts, especially on writing prompts, and focus group discussions. The researchers utilized thematic analysis to determine and understand patterns that exist within the data (Braun & Clarke). The thematic analysis involves a procedure of transcribing data from each source, coding the information, and developing themes. The accuracy and validity of the results were established by counter-checking all the codes and themes with participant teachers.

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RESULTS AND DISCUSSION

In-service Teachers' Collaborative Process of Designing PADL in Mathematics

The development of Performance Assessment-Driven Lessons (PADL) was documented to gain an understanding of how the in-service teachers integrated performance assessments into their mathematics lessons. Four Grade 9 mathematics teachers participated in the development and implementation of the PADL, which consisted of one unit with three performance assessment-based lessons designed to improve learning outcomes (Mas'ud, 2019). Figure 1 presents a graphical representation of the in-service teachers' process of incorporating performance assessment in mathematics lessons.

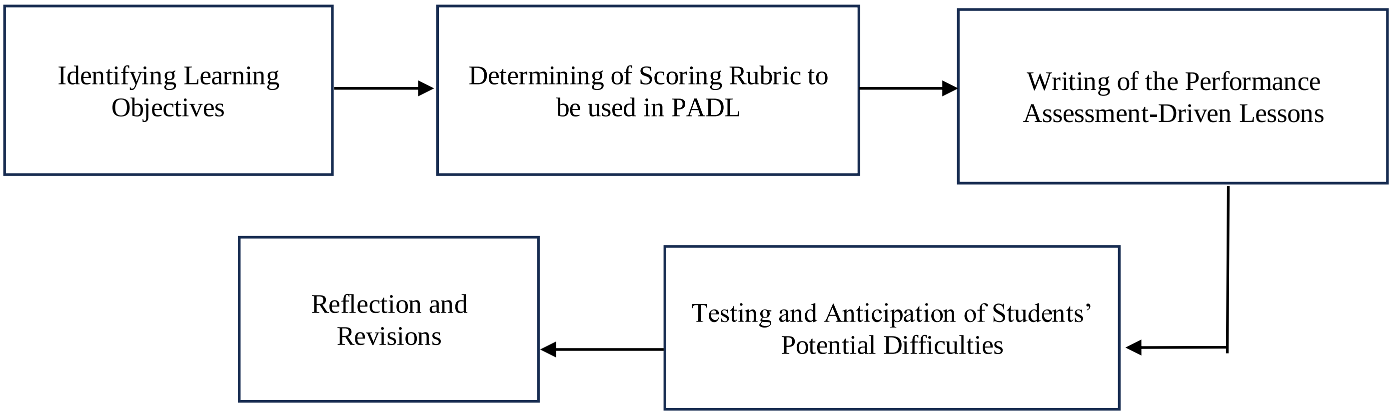

Figure 1. Diagram of In-service Teachers' Process of Incorporation of Performance Assessment in Designing Mathematics Lesson

The collaborative development began with T_2 proposing to review the learning competencies from the Most Essential Learning Competencies (MELCs) under the Grade 9 Philippine DepEd curriculum. The competencies identified for the topic "Variation" included (17) illustrating situations involving direct, inverse, and joint variations; (18) translating relationships between quantities into variation statements using tables, equations, and graphs; and (19) solving problems involving variation. The teachers collectively decided to base each lesson on these competencies, ensuring alignment with the learning objectives.

After lesson objectives were identified, a notable concentration was placed on the suitable tools for appraising student performance. T_3 suggested choosing an appropriate instrument for evaluating student outputs, leading to the adaptation of the Grade 9 Math Performance Assessment Rubric from the Stanford Center for Assessment, Learning, and Equity (2013). This decision apparently reflects the commitment to appropriate assessment and is consistent with Backward Curriculum Design principles (Wiggins & McTighe, 1990), which facilitated a structured approach to lesson planning and fostered confidence in further designing students' learning experience (Burson, 2011).

The end-unit performance assessment was an open-ended task where students were required to model and analyze real-life scenarios based on what they had learned about variation. The three lessons that made up the PADL have been tailored into Introductory Activity, Need for Knowledge, and Application segments designed to be a progressive step to leading students to answer the end-unit assessment. T_3 emphasized the importance of aligning practice activities with the end-unit assessment to ensure students' familiarity with the task. Table 1 below presents the theme of in-service teachers' focus on the incorporation of performance assessment in mathematics lessons.

An integral part of the development process was anticipating and addressing potential student difficulties. Teachers identified potential challenges during the unit plan creation and used these insights to make revisions. The final PADL was tested in T_2's classroom, where feedback from students on their difficulties was used to make final adjustments before broader implementation.

Table 1. Generated Theme on In-service Teachers' Focus in Designing the PADL

In-Service Teachers' Statements	Codes	Themes
[T_3] "If possible, we will use examples in the lesson proper such that they [students] can relate."	Real-Life Application of Learning	Enrich Students' Learning Experiences
[T_2] "It's alright, they will eventually understand the concept if they will be given chance to explain their answers, do board works, and seat works."	Strategies to Deepen Understanding on the Math Concept	
[T_4] "Let's specify the instruction in this part [referring to end-unit assessment] to avoid confusions within students. No matter how easy the activity, if the instruction is unclear, they'll not be able to do the activity..."	Clarity in Giving Activity Instructions	Consideration of Students' Potential Difficulties
[T_2] "…the kids [students] did not understand [the term] model. They claim that they can't answer because they don't know how to model…"	Challenge in Generating Responses	

Students' Learning Experience in the Implementation of the Collaboratively Designed PADL

The PADL showed how students apply what they learned in mathematics when they talk to their peers. Upon in-depth analysis of all data sources, this study determined four emerging themes that described the participants' learning experience while involved in implementing PADL.

Students are Given the Opportunity to Explain Mathematical Concept

During the implementation of PADL, instances where students actively engaged in explaining mathematical principles were prevalent. This theme highlights the role that performance assessments play in promoting a deeper understanding of mathematical concepts. When students are encouraged to verbalize their reasoning and justify their thoughts, it fosters not only their comprehension but also provides teachers with information about their actual levels of understanding. It implies that PADL enhances their conceptual grasp while simultaneously revealing their learning progress to educators (Webb et al., 2008; Pijils & Dekker, 2011).

In several instances during classroom observations, this theme was clearly manifested. For example, a notable conversation transpired during a group activity focused on modelling real-life scenarios using the concept of variation. S_4 posed the question, "*If we say, the numbers of hours [spent] working [compared] to [the amount] of earnings, how is that a direct variation?*" In response, S_6 explained, "*For example, if you have a salary of 5,000 every 2 hours, as you keep working, the number of hours increases, and your salary increases as well. So, the two variables grow together. In contrast to inverse variation, where one variable increase and the other decreases, in direct variation, both variables increase together.*"

This discussion illustrates how the format of PADL enabled S_6 to illustrate the concept of direct variation to their peers. The explanation revealed by the student not only explained the concept in detail but also presented an opportunity for peer-led learning through it. The process of explaining it forced S_6 to be active concerning the material, and the group benefited from a clarification of the concept. In this case, one can see the advantages of the implementation of PADL in favor of student-centered learning, where students are motivated to learn and communicate ideas. This process is congruent to previous research that has suggested that oral mathematics increases students' involvement with, as well as their comprehension of, and their remembering of content (Lombardi, 2007).

Another relevant example emerged during the first group's discussion of the relationship between the number of workers and the time required to complete a task, which was used to model inverse variation. S_2 asked, "*What do we mean by inverse variation? Why is this [number of workers and hours of work] an* *application of inverse variation?*" In response, S_1 eagerly explained, "*The more workers you have, the faster the job is completed. It's clearly an inverse relationship. That's inverse [variation], right? When one variable increases, the other decreases; it's like an opposite effect.*" S_1's enthusiasm in explaining the concept underscored the value of peer-to-peer interaction, as S_2's reaction indicated a clearer understanding as a result of the explanation.

These group-level interactions indicate that, in the context of the PADL, learning is collaborative, and students' conceptual understanding is enhanced. It is of greater importance because the process involves the students' explanation of mathematical concepts to peers. PADL not only facilitates learning but also develops confidence among students (Tullis & Goldstone, 2020). The very process of explaining a concept has been known to solidify one's understanding of the topic as well as enhance communication skills. Furthermore, this nature puts less of a burden on the teacher to explain directly and steers the learning environment towards more cooperative student-led discourse (Duncan, 2005).

However, teachers remain crucial in how such opportunities for explanation arise in students. Such findings also included what teachers were doing as the students were talking in small groups: subtle guiding and constructive feedback that helped support students' thinking. Teachers played a crucial role in creating an interactive classroom environment where the students felt at liberty to express themselves based on how they understood the knowledge. The immediate feedback was significant in developing conceptual explanations from students and promoting more precise and stronger discussions (Hanefar et al., 2022). The teacher is not merely a transmitter of knowledge but also a facilitator reflective of the balance required in performance assessment-driven instruction (Maier, 2020). It means, therefore, that teacher guidance will assist them in formulating their complexly held meaning in words and can contribute to deeper learning.

Students Find Avenue to Share and Consolidate Their Understanding

Another noteworthy theme that emerged during the implementation of PADL was giving students meaningful opportunities to share and consolidate their understanding of mathematical ideas. This theme reflects how the solution to a problem task emerges from discussion and builds on others' insights. Such interactions are very important to the learning process, as they allow students the chance to communicate their ideas and refine their understanding through dialogue (Majid & Chitra, 2013).

Unlike traditional quizzes where students are instructed to identify the constant of variation, in PADL, they were engaged in open-ended problems where they were challenged to think how a constant of variation should be present in certain life-like situations. In such settings, they were encouraged to solicit ideas from their small group, and each idea offered was valued and considered, thus creating an active learning environment (Allal, 2021; Methkal & Algani, 2021).

For instance, the third group of students proposed that they investigate the relationship between distance travelled and hours of driving at a constant speed. The following conversation illustrates the way the students expressed themselves to each other as a means of clarifying their knowledge about direct variation:

S_8: "*It's an application of direct variation, right? Because if you continue driving, you'll get farther distance? Can I have your suggestion*?"

S_9: "*I think so, because both variables are increasing. For example, if you spend more time driving, then you must have traveled farther. That's the meaning of direct variation, right?*"

S_8: "*Then, what should we do next?*"

This conversation demonstrates how S_8 and S_9 drew their understanding of direct variation out of each other. In the discussion, they discovered ways to probe each other's minds. Shortly after, S_{10} elaborates from this and shared an explanation:

S_{10}: "*Okay. So, we have, for example, 5 minutes of driving, and let's say your speed is 60kph. If we try to solve [it] you will be traveling 1 kilometer per minute, right? So, in 5 minutes, you'll have traveled 5 kilometers, and in 10 minutes, you'll have covered 10 kilometers. You just multiply the minutes of driving by the constant value to determine the distance traveled*."

Clearly, S_{10}'s explanation projects his explicit understanding of the concept of the constant of a variation. Through sharing, the group not only consolidated their understanding of direct variation but also provided the mathematical reasoning behind their solutions. The communication allowed students to work through their confusion to arrive at an accurate understanding of the topic (Peneda, 2023).

One evident advantage of PADL during the implementation is its ability to accommodate different learning styles. As observed in this study, several students benefited greatly from collaborative discussions. This inclusive environment ensures that students with different learning strengths are supported in their efforts to learn complex mathematical concepts (Hussein & Nassuora, 2010).

The opportunity given to students to share their understanding within a group also informs teachers about their conceptual depth. Teachers gain insights into their thinking processes, which can help them effectively identify areas where remediation might be needed. Facilitating these interactions allows teachers to intervene when necessary to redirect students back to the learning goals. Hence, with PADL, the act of assessment also becomes an effective tool for learning through actively engaging students in the co-construction of knowledge (Yaghi et al., 2011).

Students are Empowered to Ask Clarificatory Questions

Students' meaningful learning experience was particularly reflected by how they were given the chance to clarify their confusion with their peers. During the implementation, students actively sought clarification from their peers. This indicated an interactive environment where students are empowered to ask questions. In contrast to conventional assessments, where students are prohibited from asking questions, PADL encourages even the more reserved students to engage in discussions (Mahmud, 2015).

For example, the fifth group posed to discuss the relationship between the size of land and the amount of harvest a farmer could obtain. The group initially agreed, based on firsthand experience, that the estimated yield of a three-hectare land is 15 kilograms of okra. Their discussion progressed as they continued calculating harvests for larger farm sizes, focusing on whole numbers. However, S_{15} introduced a clarifying question: "*Now, how about if we have 4½ hectares of land? How many kilos could be harvested?*". By this question, the group was able to realize that solving for the constant of variation is important in dealing with fractional data. S_{15}'s inquiry, therefore, helped the group deepen their understanding of the topic. This means that opportunities given for students to raise clarificatory questions could potentially stimulate critical thinking and reasoning.

Another meaningful example came from the group that looked into the relationship between the number of workers and the corresponding hours required to complete a job. After constructing a graph from their data, S_{17} noticed a difference between their and other groups' graphs. He asked, "*Why is our drawing [referring to their graph] different from other groups*?" S_{17}'s question needed clarification as to why their graph tends to head in the opposite direction. His query sparked a heavy discussion within the group. Eventually, the group realized that their graph is a characterization of an inverse variation, while other groups' works represent direct variation. The group was then clarified that the downward slope of their graph was due to the relationship of their variables. The teacher's probing skills, on the other hand, prompted the group to recall their prior knowledge of slopes, which reinforced their understanding.

These examples highlight how PADL allows students to clarify possible misconceptions. These are also instances that effectively turn questions into a learning opportunity. This is possible because students are made to feel comfortable voicing their uncertainties. In fact, it is important to note that S_{15} and S_{17} are not known for their courage in asking questions, as confirmed by their teacher. Hence, PADL encourages active participation in the learning process regardless of a student's behavior (Ayyoub et al., 2021).

The opportunity to ask questions and clarify doubts is a cornerstone of active learning in mathematics. Studies suggest a strong linkage between allowing students inquiry and their understanding of mathematics (Wong, 2012). Empowering students to ask clarifying questions is an indication of a strengthened student-centered approach in mathematics teaching. By promoting an environment that is susceptible to raising clarification, PADL enhances the learning experience, ensuring that students are active participants in their own learning (Rop, 2002).

Students Develop Deeper Appreciation of Mathematics

The PADL implementation demonstrated a positive impact on students' attitudes and perceptions of mathematics. The developed appreciation manifests itself in an increase in motivation and interest in mathematics, with students eager to learn about the subject (Abdulrahim, 2023). Improvement in students' behavior on the subject is consistent with their renewed understanding of the importance of mathematics and its usefulness in real-life settings (Fitzmaurice et al., 2021).

This theme emerged from several instances when students exhibited a realization of the concept of variation. The theme can be reflected in the students' responses and conversations during the PADL. Likewise, this was ascertained through some of their comments during the focus group discussion. Some students narrated how they understood better that mathematics is a useful tool in real life. Examples of the discussions of the students that coincide with this theme include:

"*I can apply [this concept] if I have business in the future – so that I would be able to predict whether or not my business will be growing.*" (S_{17}, Group 6)

"Inverse variation can indeed help in determining how many persons is needed to complete a job within a specified time." (S_{19}, Group 7)

"I see. This is how we apply direct. I think I can now easily determine my father's salary [in the future]." (S_2, Group 1)

These statements are very clear indications of how students, with the aid of PADL, had brought meaningful connections between mathematics and everyday practices into their understanding. The development of this appreciation is not only short-term but one that lasts a long time. Having a real interest in mathematics makes students more likely to continue their studies of mathematics, pursue STEM-related careers, and even use mathematical thinking to solve other problems in life (Bennett, 2014).

Additionally, students' academic and professional choices are dependent on their ability to appreciate the utility of mathematics in the application of life. In this respect, for instance, the earlier a student comes to understand that mathematics is relevant in life, the more likely one is to continue with interest in the subject. Consequently, there is a higher level of mathematical persistence in pursuing courses (Johns, 2021). This is particularly important in today's world, where mathematical literacy is increasingly essential in fields ranging from technology and engineering to economics and data science (Peneda, 2023). Therefore, this finding highlights PADL's value as a pedagogical approach that goes beyond traditional assessment methods.

CONCLUSION

The teachers' collaborative process undertaken by in-service teachers in designing PADLs has shown that integrating performance assessment into mathematics education is a multifaceted process. This process followed a framework that puts utmost emphasis on students' learning experiences and potential learning challenges. The stages included (1) identifying learning objectives, (2) determining the scoring rubric, (3) writing the PADL assessment, (4) testing and anticipation of students' potential difficulties, and (5) reflection and revision.

The implementation provides insight into how PADL can affect the improvement of students' learning experiences in mathematics classes. The findings revealed that employing performance assessment means students can express and explain meaningful mathematical concepts. By this, PADL induces a greater understanding of mathematical concepts by moving beyond rote memorization to active involvement with the material.

PADL allows for interactive and collaborative learning, where students feel free to discuss and reinforce what they have learned among themselves. This interactive environment promotes cooperation among the students, allowing them to benefit from the diverse perspectives of peers. Additionally, PADL allows students to ask clarifying questions that help them adopt an inquisitive approach to learning. This mechanism of gaining clarification enhances students' interests and encourages a student-centered type of class. With PADL, students come to develop a more meaningful appreciation for mathematics since PADL requires real-life application of mathematical concepts. This improves students' perspectives about the subject and opens avenues for various interests in STEM-related paths.

Therefore, PADL in mathematics emphasize the formative role of assessment. Contrary to traditional practice, which proposes that end-unit assessment is the final test of student learning, PADL allows students to continue and refine learning even at the summative stage. This continuity of learning exhibits how PADL serves as an appropriate authentic assessment in mathematics. Therefore, this study showed that a PADL that is deliberately designed is capable of significantly enriching students' learning experiences in a mathematics class.

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