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Evaluating Photomath as a Classroom Formative Assessment Intervention: Effects on Grade 9 Learners' Achievement in Radicals

Roziel Anne Basa[1], Douglas A. Salazar[2]
[1,2] Department of Science and Mathematics Education, College of Education, Mindanao State University – Iligan Institute of Technology, Iligan City, Philippines

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ABSTRACT

Purpose of the study: This study aims to evaluate Photomath application as a formative assessment intervention integrated into the classroom cycle to determine if it can improve Grade 9 learners' achievement levels in solving radicals and to explore learners' perceptions of the application as a formative assessment intervention.

Methodology: The study used a one-group pretest–posttest design with qualitative support. Tools included a researcher-made 30-item achievement test, Photomath mobile application, and open-ended perception survey. The Wilcoxon Signed Ranks Test was applied for statistical analysis. Qualitative responses were examined through thematic analysis.

Main Findings: Learners' mean scores increased from 9.8 to 23.5, with all participants improving in the posttest. Most reached proficient or advanced levels. The Wilcoxon Signed Ranks Test showed a significant difference ($p < 0.0001$). Learners reported that the intervention helped in correcting errors and misconceptions, step-by-step understanding, and confidence in solving radicals.

Novelty/Originality of this study: This study contributed to the classroom assessment policy by using Photomath specifically as a formative assessment mechanism, requiring learners to attempt solutions independently before checking the steps through the application. Findings imply that such use of Photomath helps improve learners' achievement in radicals and enhances their understanding and confidence in solving mathematical problems.

Corresponding Author:
Roziel Anne Basa
Department of Science and Mathematics Education, College of Education, Mindanao State University-Iligan Institute of Technology, Andres Bonifacio Ave, Iligan City, 9200 Lanao del Norte, Philippines
Email: rozielanne.basa@g.msuiit.edu.ph

1. INTRODUCTION

Mathematics education, especially at the secondary level, is often a struggle for learners, especially with abstract ideas like radical expressions and concepts. Radicals is one of the core topics in Algebra and is used in different disciplines like chemistry and physics. However, students often fail to grasp these ideas, which, in turn, affects their overall performance and their attitude towards mathematics. Students have always considered radicals complicated and unnecessary [1]. The reason could be the complexity and the idea that the topic is not used in everyday life. Studies confirm that students experience persistent misconceptions and procedural errors when working with radical and exponential expressions due to the topic's abstract nature and cognitive demands [2], [3]. Research further shows that simplifying radicals remains among the least mastered competencies in junior high school mathematics and contributes to broader difficulties in algebraic manipulation [3], [4]. When learning radicals, students need to understand both arithmetic and algebraic operations, but they often struggle with them. These problems may lead to poor performance and a negative attitude towards acquiring essential mathematical skills.

With these challenges, teachers continue to look for new and innovative ways to overcome these challenges and improve learning outcomes [5]. In the context of assessment for learning tradition, formative assessment is not just the process of testing during instruction. It is the classroom process used to elicit, interpret, and respond to evidence of students' understanding that shapes the teaching and learning [6], [7]. Black and Wiliam [6] reports that there was an evidence that innovations in the classroom that aims to improve learners' feedback can have major effects on learning. Alvarez [3] further argued that formative assessment should be seen in classroom pedagogy discourse and self-regulated learning.

Formative feedback is the center of the classroom assessment process. Formative feedback is the information received by learner that is intended to change thinking and improve learning, and effective feedback should be timely, specific, supportive, and usable [8]. Hattie and Timperley [9] similarly highlight the importance of feedback that can significantly influence learning, but emphasizes that it depends on the type and delivery of feedback. Hattie and Timperley [9] further identify characteristic of good feedback as information that can answer three questions :"Where am I going?", "How am I going?", and "Where to next?". These studies emphasize the significance of feedback for learning to support error diagnosis, strategy revision, and metacognitive regulation.

Furthermore, these theoretical perspectives are integral in the 21st century digital assessment. A thematic review concludes that digital assessment has now become an important part of the learning process as it facilitates not only the teaching and learning but also assessment and productive feedback [10]. In mathematics, elaborated feedback produces greater learning effects compared to simple correctness feedback or the act of simply giving the correct answer [11]. Maskos [12] concluded in their systematic review that computer-based assessment in interactive learning environment show great potential, while also emphasizing that the field still needs more specified formative-assessment interventions with clear intended effects. These findings suggest a need to evaluate digital tools as assessment mechanisms embedded in the classroom practice.

Technology has been considered as a helpful tool in mathematics education, and its functionalies allow for redesigning and implementing mathematics instructions in unique ways [13], [14]. One particular technology is Photomath which is a free mobile application that solves mathematical expressions in real time [15]. Photomath is built to help students solve mathematical problems by giving step-by-step explanations. It provides immediate feedback, which allows students to understand complex mathematical processes that are difficult to grasp in a traditional classroom setting [16]. Furthermore, tools like Photomath will enable the students to take responsibility for their learning and enhance their problem-solving skills. Photomath has the potential to transform algebra instruction by incorporating visual math equations into image interpretation algorithms and then solving them [17]. Hartono [18] found that learning outcomes improved after using Photomath. Saundarajan et al., [19] concluded that Photomath positively impacts students' learning of algebraic equations. Zain et al., [20] concluded that students are more eager to learn when they use Photomath in their classroom. The benefits of incorporating technology into mathematics learning have significantly improved the learning outcomes based on several studies [21]. However, the educational value of Photomath does not lie in technology alone. What matters is how it used, whether it is used as an answer generation shortcut or as feedback-tool in a teacher-managed classroom assessment process. Literature suggests that evaluation of how these tools are used in a way that supports learning through evidence, feedback, and adaptation [17]-[19].

With this, the present study reframes Photomath as a formative assessment intervention. In this study, learners first attempt to solve radicals independently and then use Photomath to inspect solution steps, identify misconceptions, verify procedures, and revise strategies. The novelty of this study lies in evaluating Photomath as digital assessment intervention rather than as a general mathematics application. Thus, the main aim of this study is to evaluate the effect of Photomath as a classroom digital formative assessment intervention on Grade 9 learners' achievement in radicals. Moreover, students' perceptions of the assessment tool used in learning play a vital role in determining their effectiveness. Learners' engagement with technology depends not only on the tool's utility but also on their attitude towards its usage [22]. Specifically, this study sought to:

1. determine learners' achievement prior and after the intervention.
2. investigate the difference between the pre-test and post-test scores of learners;
3. determine learners' perceptions of the use of Photomath

2. RESEARCH METHOD

2.1 Research Design

The study employed a quantitative design with qualitative support, following a one-group pretest–posttest structure. The quantitative data were obtained from the one-group pretest-posttest to assess the effectiveness of Photomath application in Grade 9 learners' achievement levels in learning radicals. Using this design, learners were assessed before and after using the Photomath application as formative assessment intervention to identify any changes in their understanding and performance in solving radicals. Qualitative data was collected through open-ended perception questions, which supports the quantitative findings and provided deeper insight into learners' experiences.

2.2 Respondents of the Study

Respondents were 17 Grade 9 learners enrolled in Iligan Capitol College's remedial mathematics class. The learners were purposively selected since they have already received instruction in radicals but they have not attained mastery, thus they were the ideal group for testing whether Photomath for formative assessment can improve their understanding. Learners were required a smartphone capable of running Photomath to participate fully in the intervention. To be sure of confidentiality, each respondent was assigned an anonymized code L(N) that was arranged alphabetically for systematic handling of data.

2.3 Research Instruments

A thirty-item multiple-choice researcher-made achievement test was used for the pretest and posttest. The test covers radicals. There were four options for each question, designated A, B, C, and D. The researcher initially developed a 50-item multiple-choice test which was subjected to content experts validation and pilot testing. Content experts validation on the research instrument yielded an S-CVI of 1.00, this indicates that the instrument is valid. Polit and Beck [23] suggested acceptable CVI values of 1 for 3 to 5 experts. After the validation, pilot testing and classical instrument analysis were performed. Since the test was scored dichotomously, *KR-20* was used to measure internal consistency coefficient [24]. Moreover, Cronbach's alpha was also used as corrobating index because alpha is a general reliability coefficients with KR-type coefficients as special cases. The pilot analysis results showed a *KR-20* of 0.8944 and Cronbach's alpha of 0.8918, indicating a high internal consistency. Item analysis further yielded an average difficulty index of 0.4907, classified as average and an average discriminating index of 0.4414, classified as discriminating The final version consisted of a thirty-item multiple-choice test. The questionnaire was then administered to the Grade 9 learners to determine their prior knowledge of the topic. The same questionnaire, with the items rearranged, was administered as a posttest following the intervention.

To obtain qualitative information on the effectiveness of the PhotoMath application as a formative assessment among students, a perception questionnaire was administered after the posttest. The questionnaire contained open-ended questions that determined learners' perceptions of using PhotoMath as a formative assessment, the difficulties they faced when using it, and their views on the effectiveness of the application in helping them learn radicals. Learners answered the questionnaire using English, Filipino, the vernacular, or any combination of such languages. These questions were face-validated by the mathematics teacher and professor.

Table 1. Instruments Used in the Study

Instrument	Purpose	Description
Achievement Test	To measure learners' achievement before and after the intervention.	30-item multiple choice test on radicals. The final version was developed from a 50-item multiple choice test subjected into expert validation, instrument and item analysis.
Perception Questionnaire	To collect qualitative data on the use of Photomath as formative assessment.	An open-ended questionnaire that explored learners' perception on the use of Photomath as a formative assessment and the difficulties they have experienced.

2.4 Intervention

The study was divided into three phases: Before Intervention, During Intervention, and After Intervention. Before the intervention, a letter requesting permission to conduct the study at the Grade 9 level was drafted and sent to the director of student affairs at Iligan Capitol College to ensure the research's validity. Additionally, the learners received letters of consent and agreement. Then, the learners were given a pretest to assess their baseline knowledge of radicals. They were also given an orientation to provide context and purpose for the study, introduce the application, and demonstrate how it would be used during mathematics instruction.

In the Intervention Phase, the learners used the Photomath application for 2 weeks, covering topics aligned with DepEd's most essential learning competencies. The Photomath application was integrated into classroom discussions and guided practice used for checking understanding, verifying errors, and providing immediate feedback on learners' solution. Learners were asked to use the application only after trying to solve it independently. When difficulties arose, they used Photomath to examine the process, compare it with their own answer, and identify areas needed for improvement. Learners were given homework and were allowed to use the application to verify their answers and reflect on their mistakes. In this manner, assessment is viewed as an integral process in the curriculum implementation and formative assessment is used to monitor learning progress and improve instruction.

After the intervention, learners answered the posttest to determine if there was a significant change in their achievement level. They also answered the perception questionnaire to provide qualitative data which helped in understanding the quantitative results.

2.5 Data Analysis

The participants' achievement level was determined using the pretest and posttest. The table below was used to interpret the data. This served as the basis for classifying and determining the description of the intervals to which they belong.

Table 2. Achievement Level Interpretation

Achievement Test Score	Percentage	Achievement Level Interpretation
26-30	90% above	Outstanding
23-25	85% - 89%	Proficient
21-22	80% - 84%	Approaching Proficient
18-20	75% - 79%	Developing
0-17	Below 74%	Beginning

The table displays the achievement-level interpretation, with a passing average of 75%. The Department of Education-approved K–12 curriculum grading scheme serves as the basis for this. The score ranges are established using counts, with the lowest interval (0-17) categorized as 'Beginning' and the highest interval (26-30) as 'Outstanding'. This table was used to interpret the learners' achievement levels.

In this study, both quantitative and qualitative data were gathered and analyzed using the following statistical treatments. Because the study examined achievement change within the same group of learners before and after a formative assessment intervention, the data were inherently paired, hence Wilcoxon Signed Ranks Test was used. It was selected as the most appropriate tool since it is designed for paired scores and does not require assumption that the difference scores are distributed normally, and with sample sizes that are relatively small [25] which were all characteristics of the data set in this study. The results helped assess the extent to which the application has improved learners' performance in radicals. Correlation coefficient (r) was also used to determine the magnitude of the difference between the two scores. Also, learning gain indicators such as raw mean gain, and normalized gain were also computed. This analysis provided a summative overview of learners' performance and any trends or changes in their achievement levels. Responses from the perception questionnaire were analyzed using thematic analysis to determine emergent themes. The process involved multiple readings of the data, coding significant segments, grouping codes into categories, and deriving overarching themes.

3. RESULTS AND DISCUSSION

3.1 Learners Achievement Level

The pretest and posttest results reveal significant improvements in learners’ achievement levels after the Photomath intervention. As shown in Table 1, all learners (100%) were categorized as Beginning during the pretest, indicating very low mastery of radicals despite previously completing the topic in their regular mathematics class. This confirms that the remedial class population indeed possessed significant learning gaps and required targeted intervention.

Table 3. Learners’ Achievement Level Interpretation

Achievement Test Score	Pretest Frequency (n)	Percentage (%)	Posttest Frequency (n)	Percentage	Achievement Level Interpretation
26-30	0	0	6	35	Advanced
23-25	0	0	7	41	Proficient
21-22	0	0	2	12	Approaching Proficiency
18-20	0	0	0	0	Developing
0-17	17	100	2	12	Beginning
Total	17	100	17	100	

After the two weeks of Photomath-supported remedial instruction, the distribution of the scores shifted noticeably. Only two learners remained in the Beginning level, while the majority moved into higher levels: Approaching Proficiency at 12%, Proficient at 41%, and Advanced at 35%. This upward redistribution shows that the intervention did not merely improve average scores, but moved most learners into higher performance categories.This movement across achievement categories reflects improved learning gains and suggests that Photomath provided effective scaffolding for reconstructing previously misunderstood concepts.

Table 4. Comparison of Pretest and Posttest Results of Learners' Achievement

	Mean	Std. Dev.	Interpretation
Pretest	9.8824	5.43004	Beginning
Posttest	23.5882	3.74264	Approaching Proficiency

Table 4 further demonstrates this. Starting at an average of 9.88 for Beginning, the mean score grew to 23.59 at Approaching Proficiency. This gain was significant and reflected a wide improvement in both conceptual and procedural learning. The reduction in standard deviation from 5.43 to 3.74 further supports the notion that learners performed more consistently and thus uniformly attained the competencies.

Table 5. Learning Gain Indicators of Learners' Achievement

Indicator	Value
Pretest mean percentage	32.94%
Posttest mean percentage	78.63%
Learning gain percentage	45.69%
Raw mean gain	13.7058
Normalized gain (g)	0.68

The learners obtained a learning gain percentage of 45.69%, increasing from a pretest mean percentage of 32.94% to a posttest mean percentage of 78.63%. The raw mean gain was 13.7058, indicating a notable increase in the mean achievement score. Moreover, the normalized gain was 0.68, which falls under the medium gain category based on Hake's interpretation of normalized gain [26].

The findings show that the Photomath intervention has positive impact on learners' achievement as evident by the improvement in the increases in scores, learning gain percentage and normalized gain. This means that the use of Photomath as a formative assessment to provide immediate feedback was effective. This is consistent with various studies which showed that Photomath can improve mathematics performance and independent learning [27], [28]. Similar interventions reported significant increase in learners' mathematics scores when step-by-step digital solutions were used to reinforce instruction and address learning gaps [29]. The results support the view that structured digital feedback in formative assessment can enhance learners' mastery and help correct persistent misconceptions.

3.2 Difference between Pretest and Posttest Mean Scores

To determine whether the observed improvement was statistically significant, the Wilcoxon Signed-Ranks Test was conducted.

Table 6. Wilcoxon Signed-Ranks Test on Pretest and Posttest

Pretest-Posttest	N	Mean Rank	Rank Sum	Z	p	r
Negative Rank	0	.00	.00	-3.630	.0001	0.62
Positive Rank	17	9	153			

The Wilcoxon Signed-Ranks Test was used to evaluate whether the observed improvements were statistically significant, an approach widely recommended for small samples or non-normally distributed paired data in educational research [30]. The analysis showed a meaningful effect of the intervention ($Z = -3.630$, $p < 0.001$), with all learners demonstrating positive gains and no negative ranks. The computed effect size ($r = 0.62$) represents a significant practical impact, consistent with thresholds established in nonparametric effect-size interpretation literature [31]. These findings indicate that the Photomath-supported remediation produced significant improvements in learners' understanding of radicals.

The effectiveness of this intervention is consistent with research indicating that formative assessment is known to enhance learning when student performance is elicited, interepreted, and used to guide next instructional steps [6], [7]. In this study, learners attempted to solve the problems and then used the step-by-step feedback to verify their procedures. Research shows that learning gains are maximized when learners first attempt problems on their own before receiving targeted digital feedback, as this format prompts productive struggle and supports the construction of mathematical reasoning [32]. Barana et al., [33] conceptualized interactive feedback in mathematics as a step-by-step process done after attempts and highlighted how it supported mathematics learning in a digital environment. Together, the statistical findings and supporting literature underscore that the Photomath intervention served not only as a digital tool but also as a formative assessment mechanism within instruction. The use of this intervention supported learners' reconstructing concepts, regulating learning, and improving achievement.

3.3 Learners' Perception on the Use of Photomath

The researcher used a questionnaire to acquire the learners' perceptions of using Photomath. The data gathered from this questionnaire helped inform the study's quantitative results. To fully grasp each learner's response, inductive thematic analysis was used to identify emergent themes.

Table 7. Thematic Analysis of Leaners' Responses in the First Question

Themes	Sample Responses
Enhanced Step-by-Step Understanding	*"Photomath helped me understand the process of solving radical expressions by providing step-by-step solutions and explanations. It ensures that I understand each step and not just the final answer" (L4).* *"Using Photomath helps by showing step-by-step solutions to radical expressions, which aids in understanding the process of simplifying square roots, rationalizing denominators, and applying radical properties" (L3).*
Correction of Misconceptions	*"Photomath showed me that I was incorrect. I didn't understand why or where I got it wrong. Thank goodness there was an option button in Photomath which upon pressing, explained the mistake" (L1).* *"There was a time when I had a radical expression that I didn't understand. I used Photomath to scan the solution and saw the steps I needed to understand" (L4).*

Thematic analysis of learners' responses to the first question revealed two key themes: enhanced step-by-step understanding and correction of misconceptions. Learners consistently reported that Photomath's in-depth, step-by-step explanations helped them trace the procedures for simplifying radicals, rationalizing denominators, and using the properties of radicals when solving problems (L4, L3). This structured breakdown supported learners' procedural understanding which helped them to grasp not only the final answer but also an explanation of how each step was obtained, an area in which many struggled before the intervention.

Learners also highlighted that Photomath helped them identify and clear misconceptions. Many mentioned that they did not realize where their mistakes were until the application identified the wrong step and explained the correct one (L1, L4). This is consistent with the literature, which suggests that immediate feedback can help learners clear misconceptions and increase the accuracy of subsequent responses through prompt correction and reinforcement [34]. In the area of digital feedback in mathematics, it has been suggested that immediate, process-focused feedback supports students in closing the gap between current and intended performance by triggering comparisons, reflections, and adjustments in strategies [33]. Recent research on Photomath itself notes that its step-by-step explanations, combined with immediate feedback, significantly improve algebra achievement and help learners conceptualize the processes underlying solutions more clearly [35]. These results suggest that the intervention served as part of a feedback loop which allowed learners to use their own errors to change their understanding, correct misconceptions, and improve ongoing performance.

Table 8. Thematic Analysis of Leaners' Responses in the Second Question

Themes	Sample Responses
Pre-Solution Attempt	*"I solve the equation first, then use Photomath to see if my solution is correct. Then I review it" (L9).* *"I solve it first then check using the application" (L12).*
Collaborative Learning	*"I would ask my classmates to share insights on how we can approach the problem" (L10).* *"I would be sharing my answer to my classsmates then compare it to his before we use photomath" (L15)*

The analysis of responses to the second question revealed two prominent themes: pre-solution attempts and collaborative learning. Learners consistently shared that they attempted to solve problems independently before using Photomath to verify their answers (L9, L12). This pattern is important in the formative- assessment perspective because it shows how they use their current understanding before receiving feedback. In other words, the intervention followed an assessment cycle in which learners attempted the task, generated evidence of their present performance, received feedback, and then used that feedback to confirm, revise, or improve their reasoning.

Sadler [36] explains that formative assessment is effective when learners compare their present performance with a desired standard and then take action to close the gap. Similarly, Nicol and Macfarlane-Dick [37] argue that good feedback practice supports self-regulated learning by helping learners monitor their current understanding, identify what needs improvement, and decide on next steps. In this sense, Photomath functioned not as a substitute for thinking but as part of a feedback loop within the classroom assessment cycle, where learners attempted the task, received feedback, and revised their reasoning.

Learners also described engaging in collaborative learning, such as discussing solution strategies and comparing answers with classmates before consulting the application (L10, L15). These peer interactions allowed them to reinforce understanding, clarify steps, and learn alternative approaches from one another. This aligns with Jumhur et al., [38], who reported that problem-based and interactive learning environments enhance critical thinking and overall learning outcomes. Similarly, Albay [39] found that combining independent problem-solving with collaborative interactions results in stronger academic performance, as learners benefit from both individual effort and shared reasoning. Moreover, research on cooperative and collaborative problem solving in mathematics shows that working with peers enhances conceptual understanding, strategic flexibility, and problem-solving performance, particularly when students explain their reasoning and negotiate multiple solution paths [40]. These collaborative processes were extended by feedback, as learners used Photomath after individual and peer interactions to verify procedures and check understanding, This sequence of attempts, peer discussion, feedback, and revision shows that the intervention act as a digital formative assessment mechanism. It also shows metacognitive regulation as learners monitored their progress while verifying their reasoning, and choosing appropriate strategies before arriving at the final answer Heeren et al., [41] discovered that computer-based formative assessment which included metacognitive and heuristic feedback enabled students to control their solution methods while monitoring their progress and justifying their decisions to others. Together, these findings suggest that Photomath was used in a way that complemented learners' cognitive processes by functioning within a classroom assessment cycle.

Next, learners were asked about the difficulties and challenges they experienced using Photomath. Based on their responses, the typical answers involved technical limitations and input errors. Table 8 presents the emerging themes derived from learners' responses.

Table 9. Thematic Analysis of the Learners' Responses in the Third Question

Themes	Sample Responses
Input Errors and Misinterpretations	*"I soon realized that you really need to write properly the question in order for Photomath to generate the correct answers" (L1).*
	"Photomath showed a different solution, not the same with mine, but I just observed and compared it to mine" (L8).
Technical Limitations	*"Sometimes it takes a long time for it to load an answer because of the connection" (L13).*
	"The application lags because of the internet connection" (L12).

The thematic analysis revealed two key difficulties learners experience when using Photomath: input errors and misinterpretations , as well as technical limitations. Learners noted that incorrect or unclear handwritten input sometimes caused the application to misread expressions, leading to solutions that is different from their own (L1, L8). This demonstrates that Photomath's accuracy depends heavily on the precision of the input, and that learners must develop careful digital-entry habits to avoid confusion. Similar issues are noted in research on digital mathematics tools, where the effectiveness of automated feedback is strongly dependent on the accuracy and clarity of learners' input, as systems can only generate meaningful feedback when mathematical expressions are correctly interpreted by the software [33], [41].

Technical limitations also affected use, with several learners reporting slow loading times and app lag due to unstable internet connections (L12, L13). These disruptions can interrupt the learning flow and reduce the immediacy of feedback, which is critical for remedial learners who rely on timely correction. Meta-analytic work has shown that although digital tools generally yield positive effects on learning (with a medium-to-large average effect size), contextual factors such as student-to-device ratio, infrastructure, and implementation conditions can moderate their impact [42].

Overall, these challenges highlight that while Photomath can assist learning, its effectiveness as a formative assessment mechanism depends on both accurate input and reliable connectivity. Instructional support is therefore necessary not only to help learners use the application properly, but also to ensure that the feedback it provides is critically interpreted.

Table 10. Thematic Analysis of the Learners' Responses in the Fourth Question

Themes	Sample Responses
Independent Problem-Solving	*"Reviewing the step-by-step solutions in Photomath helps me prepare for solving similar problems on my own by providing a detailed breakdown of the problem-solving process" (L4).* *"It serves as a guide for me to solve on my own" (L8).*
Boost Confidence	*"I gained more confidence because I can now share how to solve it with others" (L16).* *"It boosted my confidence, helping me answer independently" (L14).*

Table 10 shows the emergent themes from the fourth perception question. The analysis of learners' responses highlighted two major themes: independent problem-solving and boosted confidence. Learners explained that reviewing Photomath's step-by-step solutions helped them understand the reasoning behind each procedure, enabling them to solve similar problems independently in the future (L4, L8). Similarly, Nicol and Macfarlane-Dick [37] suggests that formative feedback can enable the learner to take greater control of their learning and can promote self-regulated learning.

Learners also reported increased confidence after using Photomath. They felt more prepared to solve problems, share solutions with peers, and participate actively in class discussions (L16, L14). This aligns with studies showing Photomath use was associated with increased confidence and more independent engagement in mathematics [43], [44]. Also, systematic reviews suggest that supportive and feedback-rich environment promotes more positive attitude towards mathematics [45]. In this manner, learners used feedback from Photomath to evaluate their current performance, deepen their understanding, and work similar problems with greater confidence.

Table 11. Thematic Analysis of the Learners' Responses in the Fifth Question

Themes	Sample Responses
Step-by-Step Solution Feature	*"The step-by-step solution is very effective for understanding radicals" (L8).*
Take a Photo Feature	*"The way you scan the problem or picture it, then it will automatically answer" (L6).* *"The feature where you just take a picture or scan the problem" (L13)*

The themes for the fifth question revealed two features of Photomath that learners found particularly helpful: the step-by-step solution feature and the take-a-photo feature. Learners expressed that the step-by-step breakdown was especially effective for understanding how to simplify radicals and apply related procedures (L8). This feature was deemed helpful as it gave feedback in a structured sequence, allowing learners to compare and revise their answers. This is consistent with research showing that formative feedback is beneficial when tiy allows learners to check errors and reflect on the procedures [8]. Moreover, worked examples and stepwise guidance can support learning, specially for less experienced learners [42].

Learners also valued the convenience of the scan-or-photo feature, noting that taking a picture of the problem allowed the app to generate solutions quickly and accurately (L6, L13). This ease of input reduces the frustration often associated with manually entering expressions, making the learning experience more efficient and engaging. Timely feedback is essential in assessment for learning as it allows learners to respond to errors while they are still active on the task [8], [46] . Research on digital mathematics argues that immediate and interactive feedback can facilitate learning as learners are still engaged in task, making feedback more usable [33], [47]. Together, these themes highlights how the features supported the classroom assessment cycle. It emphasized how learners used feedback to improve their understanding.

This study demonstrates that Photomath can be used as digital formative assessment intervention, when learners used it after they make an initial attempt. The findings show that it can support achievement, correct misconception, and improve learners's confidence. This aligns with studies that argues that digital formative assessment in mathematics can improve achievement and motivation [48], support reasoning and self-efficacy [49], and help learners monitor and control their problem solving strategies [47]. It aligns in Ackerlauer et al., [50] showing that digital assessment data can be used to provide formative feedback as part of the assessment cycle in the mathematics classroom. The study further contributes to the classroom assessment practive by showing how digital feedback can be used in the process of assessment-for-learning to support learners in monitoring and improving their performance.

The results of the study have implications for mathematics teachers, school administrators, and curriculum designers. The findings suggest that Photomath can be effectively used as a digital formative assessment intervention in teaching radicals. The findings highlight that the application should not be used as a source only for answer but as part of the process of assessment for learning. The results also emphasize the importance of guiding learners to use step-by-step feedback, peer discussion, and teacher support as part of the classroom formative assessment process. It also emphasizes how feedback is used to monitor current understanding, adjust strategies, and strengthen mathematical learning.

However, the findings should be interpretated with caution. The study was limited with a small sample from one remedial class, this limits the generalizability of the results. The one-group pretest-posstest design limits the ability to attribute solely the observed gain to the intervention. The topic of the study was also limited to radicals which means the results may not be directly transferable to other topics.

Future research may use Photomath as a formative assessment intervention in other math topics and with a larger and more diverse learners. It is recommended to use comparison-group or quasi-experimental designs to provide stronger evidence of effectiveness. It is also suggested that studies explore long-term retention and how factors like input accuracy, device access, and internet stability incluence the success of digital formative assessment in mathematics classroom.

4. CONCLUSION

The results of this study demonstrate that Photomath, when used as a formative assessment intevention in remedial instruction effectively enhanced learners' achievement in radicals. Quantitative results showed higher posttest performance, learning gains, and a statistically significant difference between pretest and posttest scores, while qualitative findings showed that learners used the step-by-step feedback to clarify procedures, correct misconceptions, and gain confidence in solving problems. Photomath was effective because it was used in the classroom formative assessment process. Learners independently attempted the tasks then use the feedback to check, revise, and improve their understanding. In this way, the intervention supported assessment for learning by helping learners track their performance and strengthen their conceptual understanding.

The qualitative findings supported this result by showing positive perceptions on the intervention. Data revealed that the intervention enabled learners to better understand procedures in math through step-by-step explanations, correcting their misconceptions, and checking their answers after attempting a question. Learners also highlighted that they feel more confident to solve problems and improved their understanding through the process of solving the task first before using the application and collaborative interaction. The feedback was easier to access because of features like step-by-step solution and take a photo function which allowed the learning process to be manageable and engaging. Despite these positive outcomes, the study has limitations, including a small sample size from a single remedial class, reliance on device access and stable connectivity, and a focus limited to radicals.

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