Jurnal Ilmiah Profesi Pendidikan
Volume 10, Nomor 2, Mei 2025
ISSN (Print): 2502-7069; ISSN (*Online*): 2620-8326

Effectiveness of the Problem-Based Learning Model Assisted by VBA-Based Media for Excel in Equivalency Education Context

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Article History
Received : March 06th, 2025
Revised : April 27th, 2025
Accepted : May 05th, 2025

Abstract: This study investigates the effectiveness of a Problem-Based Learning (PBL) model, augmented by Visual Basic for Applications (VBA) for Excel, in enhancing students' mathematical understanding and skills. PBL emphasizes problem-solving, while VBA for Excel is a programming tool utilized for automating tasks within Excel spreadsheets. The study was conducted amongst a group of students at the elementary level equivalency education. Data were collected through pre and post-tests, classroom observations, and student feedback on the use of the PBL model and VBA for Excel. The results indicate a significant improvement in students' mathematical understanding and skills using the PBL model supported by VBA for Excel. Participants exhibited a marked enhancement in their ability to develop mathematical skills. Additionaly, student satisfaction surveys revealed a positive response to the integration of PBL and VBA for Excel, reporting higher motivation, deeper engagement, and a positive perception of the relevance of the learning material. This research provides evidence that combining PBL and VBA for Excel can be an effectivite approach and medium for mathematics education, underscoring the importance of integrating real problem-solving using relevant technological applications in the process. The practical implication is that a VBA for Excel supported PBL model can foster enhanced understanding and skills in mathematics.

Keywords: Equivalency Education, Problem Based Learning, VBA for Excel.

INTRODUCTION

Education is a multifaceted process encompassing both formal and informal means through which individuals acquire knowledge, skills, values, and comprehension (Hasan & Nurhayati, 2012; Moksin et al., 2024; Nurhayati, 2021; Safuri et al., 2022). Education plays a pivotal role in the holistic growth and progress of both individuals and society (Achmad & Fitria, 2024; Musa & Nurhayati, 2021; Nurhayati et al., 2022; Sulaimawan & Nurhayati, 2023). schooling can be observed over multiple tiers, encompassing early schooling, primary education, secondary education, as well as college and advanced training. Education is more than just the transmission of knowledge; it also encompasses the cultivation of character, the honing of skills, and the empowerment of individuals to make meaningful contributions to society (Nurhayati & Musa, 2020; Rohaeti & Nurhayati, 2023; Safitri & Nurhayati, 2023; Sunari & Nurhayati, 2023). Education is frequently regarded as a durable investment that yields enduring advantages for both individuals and society.

Mathematics serves as a means for cultivating abstract modes of cognition, characterized by deductive reasoning and the organization of structured concepts in a logical manner(Hujono, 2003). In the study conducted by (Waskitoningtyas, 2016), it is observed that mathematics serves as a discipline employed for the purpose of resolving issues pertaining to constructive and complex numbers. Mathematics learning is the process of gaining understanding and skills in mathematical concepts, methods and approaches. The process of mathematics education entails a dynamic exchange between educators and learners, encompassing the utilization of diverse pedagogical approaches, techniques, and resources to facilitate students' comprehension and proficient application of mathematical principles. The acquisition of mathematical knowledge extends beyond rote memorization of formulas and numerical computations, encompassing the cultivation of a profound comprehension of fundamental principles, patterns, and interconnections among mathematical constructs. Sari (Hera & Sari, 2015) posits that the objective of mathematics instruction is to cultivate students' capacity to comprehend mathematical concepts, engage in logical thinking, tackle complex issues, effectively convey mathematical ideas, and develop a positive disposition towards the subject.

According to Chotimah et al. (2018), the Ministry of National Education emphasizes the significant role of mathematics in fostering cognitive growth and serving as the fundamental basis for the advancement of contemporary technology. In order to cultivate the capacity for logical, analytical, systematic, critical, and cooperative thinking, it is imperative that students possess a solid foundation in mathematics. The advent of information technology in the dynamic digital era has precipitated a notable transformation in the landscape of mathematics education, facilitating the emergence of enhanced and interactive pedagogical approaches. Problem-Based Learning (PBL) is a learning model that has garnered more attention in recent years. This approach necessitates active student engagement in the process of solving real-world problems that are situated within specific contexts (Fitriana & Nurhayati, 2024; Prastowo et al., 2025). Problem-Based Learning (PBL) is an educational framework that places a strong emphasis on the acquisition of knowledge and understanding via the active engagement of students in addressing real-world situations (Fitriana & Nurhayati, 2024; Safitri & Nurhayati, 2023). Within the realm of mathematics education, problem-based learning (PBL) serves as a pedagogical approach that facilitates the cultivation of a more profound comprehension of mathematical concepts by their connection to real-life scenarios. However, in order to enhance efficacy, the utilization of interactive learning medium is necessary. One potential learning tool that can be utilized is software based on VBA (Visual Basic for Applications) for Excel. Excel is widely recognized and highly adaptable software that is extensively utilized in the realms of academia and commerce. The utilization of Visual Basic for apps (VBA) facilitates the creation of Excel-centric apps that may be customized to cater to educational requirements. The integration of problem-based learning (PBL) with Visual Basic for Applications (VBA) in the context of Excel-based media is anticipated to foster enhanced levels of interactive and comprehensive learning experiences for students in the field of mathematics.

Problem Based Learning Model is a learning model that is centered on problem solving. The PBL model is an active learning model that emphasizes problem solving as central to the learning process. The PBL model encourages students to be actively involved in their learning process. The PBL model shifts the role of teachers from dominating teachers to facilitators or mentors who support student learning. Students work in small groups to solve problems together so that collaboration, communication, and TEAMWORK occur. According to Ward PBL is a learning model that involves students to solve problems using scientific stages, so that students can learn to find out knowledge related to the problem as well as have problem-solving skills (Mareti & Hadiyanti, 2021). While Glazer said that the PBL model emphasizes learning as a process of problem solving and critical thinking (Nafiah & Suyanto, 2014). While Posamentier, Stepelman &; Kelly argued that Learning with the *Problem Based Learning* (PBL) Model, before starting to solve problems, students are given the opportunity to understand the problem (Meke et al., 2019; Safitri & Nurhayati, 2023). Through PBL students gain experience solving realistic problems and emphasize the use of communication, cooperation, and available resources to formulate ideas. The steps of the PBL model according to Kodariyati & Astuti, stage I orients students to problems, stage II organizes students to learn (Kodariyati & Astuti, 2016). Stage III, guiding individual and group investigations, stage IV, developing and presenting work, stage V, analyzing and evaluating problem-solving processes.

Visual Basic for Applications (VBA) is a programming language integrated in Microsoft Excel that allows it to help automate tasks in Excel, create special functions, and develop more complex Excel-based applications. Using VBA for excel can create macros that execute a series of commands automatically, processing data efficiently. According to Marcovits Visual Basic Applications have great advantages that are able to see objects, tinker with objects in programming languages and can add functions to Microsoft office applications (Marcovitz, 2004). The use of VBA for excel in mathematics learning allows for a more dynamic, problem-based, and interactive approach to mathematics teaching. This can help improve comprehension skills in mathematics teaching.

Although existing studies have explored the benefits of PBL in mathematics education, and separately acknowledged the utility of VBA-Excel in enhancing computational and procedural fluency, limited empirical research has focused on the integrated implementation of PBL with VBA-based interactive media. Furthermore, few studies have examined how this integrated approach influences students' mathematical understanding, problem-solving skills, and collaborative learning experiences in real classroom settings. There is also a paucity of research addressing how students perceive and engage with such media-enhanced PBL environments, particularly in developing country contexts where digital literacy and resource access vary significantly.

Building upon these considerations, this study aims to examine the implementation of a Problem-Based Learning model supported by VBA-based Excel media in mathematics education. Specifically, it investigates the impact of this integration on students' learning processes, engagement, and problem-solving capabilities. By addressing the aforementioned gap, this study contributes to the development of contextually grounded and technology-enriched pedagogical strategies for mathematics education. The subsequent sections outline the theoretical foundation, research design, findings, and implications for both practice and future inquiry.

METHOD

Research Design

This study adopted a quasi-experimental design utilizing a one-group pretest-posttest format, which is commonly employed to assess changes in learning outcomes following a specific instructional intervention. This design is particularly appropriate for practical educational settings where random assignment is not feasible but where the researcher seeks to evaluate the impact of a treatment on a single group (Iswahyudi et al., 2023; Nurhayati, Kurnianta, et al., 2024). The objective was to determine whether there was a statistically and pedagogically significant improvement in student learning outcomes and attitudes after the application of the PBL model integrated with Excel-based VBA media. The study was conducted in an equivalency education program located at a Community Learning Center (Pusat Kegiatan Belajar Masyarakat or PKBM) in Cimahi City, Indonesia. This setting was selected due to its relevance in providing foundational education for adult and adolescent learners outside the formal school system. The research participants consisted of 15 students enrolled in a mathematics equivalency course at the selected PKBM. The participants were selected using purposive sampling, which enabled the inclusion of learners with basic literacy in mathematics and access to the digital tools required for the intervention. The participants represented a heterogeneous group in terms of age and prior educational experience, which is characteristic of equivalency education learners. Ethical considerations, including informed consent and voluntary participation, were fully observed. The instructional intervention integrated the Problem-Based Learning (PBL) model with VBA-based media for Microsoft Excel as the core learning approach for teaching multiplication concepts. The intervention was conducted over multiple class sessions, with each stage of the PBL cycle explicitly implemented and supported by the digital learning media.

The digital learning media employed was a VBA-based Excel program designed to simulate a modern version of Napier's bones, which is a visual aid for teaching multiplication. The VBA programming enabled automated feedback, real-time visual representation of multiplication procedures, and immediate reinforcement of correct or incorrect problem-solving strategies. According to Marcovitz (2004), such features enhance engagement and comprehension by allowing students to interactively explore mathematical patterns and algorithms. Two primary instruments were used to measure the effectiveness of the intervention: a) Mathematics Comprehension Test A custom-designed test consisting of five questions on multi-digit multiplication was administered before and after the instructional intervention. The test aimed to measure improvements in students' computational accuracy, conceptual understanding, and problem-solving skills. b) Student Attitude Questionnaire To assess student responses to the PBL-VBA learning experience, a Likert-scale-based questionnaire was used, comprising ten items adapted from Andriani et al. (2021). The items measured students' perceptions of the learning model, media usability, enjoyment, and perceived improvement in skills. Each item used a four-point scale:

Strongly Agree (4) / Agree (3) / Disagree (2) / Strongly Disagree (1) for positive items and Reverse-coded for negatively phrased items to maintain validity and reduce bias. The scores from both instruments provided quantitative indicators of learning effectiveness and student engagement.

Data collection was carried out in three main stages: 1) Pretest Administration: Prior to the intervention, the pretest was administered to evaluate students' baseline knowledge of multiplication. During this phase, student behavior and difficulties in solving multiplication problems were observed and recorded. 2) Implementation of PBL-VBA Intervention: The intervention spanned several sessions, incorporating the PBL cycle and the use of Excel-VBA media. During this phase, observational notes and photographs were taken to document student interactions, group discussions, and engagement with the digital media. 3) Posttest and Questionnaire Administration: After the completion of the intervention, the same five-item mathematics test was re-administered as a posttest. Additionally, the student response questionnaire was distributed and collected for analysis.

Table 1. Learning Outcome Improvement Criteria

Criterion	N-Gain Value
High	g > 0.7
Medium	0.3 < g ≤ 0.7
Low	g ≤ 0.3

Based on the n-gain score criteria above, learning using the VBA for excel-based media-assisted PBL model is said to increase if student learning outcomes obtain an n-gain score of > 0.3 with medium or high criteria. The n-gain value that has been obtained will later be interpreted into a form of presentation, which aims to determine the grouping of the effectiveness of the n-gain value. The efficiency grouping is shown in Table 2.

Table 2. N-Gain Score Effectiveness Interpretation Criteria

Criterion	N-Gain Value
Ineffective	< 40
Less Effective	40 – 55
Quite Effective	56 – 75
Effective	> 76

Questionnaire for student responses related to learning PBL model assisted by VBA for excel media using questionnaires with modified Likert scale. The haunted score of student responses according to Nunung (Andriani et al., 2021) is shown in Table 3.

Table 3. Student Response Questionnaire Score

Student Answer Categories	Score for Answer	
	Positive	Negative
SS (strongly agree)	4	1
S (agree)	3	2
TS (disagree)	2	3
STS (strongly disagree)	1	4

The following formula is used to calculate the percentage of total score per item according to Diana Netriwati & Suri (Diana et al., 2018):

$$P = \frac{\sum f}{N} \times 100\% \qquad (1)$$

Where P is the final score, ∑f is the total score obtained, N is the maximum total score. The following categories of student response percentage according to Lukitawati (Andriani et al., 2021) are shown in Table 4:

Table 4. Student Response Percentage Category

Percentage of student responses	N-Gain Value
85% ≤ NRS	Very positive
70 % ≤ NRS < 85%	Positive
50 % ≤ NRS < 70%	Less Positive
RS < 50%	Not Positive

Results

Prior to the instructional intervention, a pretest was administered to assess students' prior knowledge and ability to perform multiplication involving two- or three-digit numbers. The test consisted of five open-ended items designed to evaluate computational accuracy, conceptual understanding, and procedural fluency. The results revealed that the majority of students demonstrated significant difficulties in solving multiplication problems involving multi-digit numbers. Observations during the pretest indicated confusion regarding the placement of partial products, sequencing of multiplication steps, and the correct summation of intermediate results. Furthermore, only a few students

DOI: https://doi.org/10.29303/jipp.v10i2.3316

produced entirely correct responses across all five test items. These findings support the initial assumption that learners enrolled in the equivalency program exhibited foundational mathematical gaps, particularly in multi-step operations such as multiplication. This context established the necessity for an instructional approach that would be both interactive and conceptually grounded to support meaningful learning progression. Exposure related to the effectiveness of learning using the PBL model with the help of VBA for excel-based media is involved in the following activities:

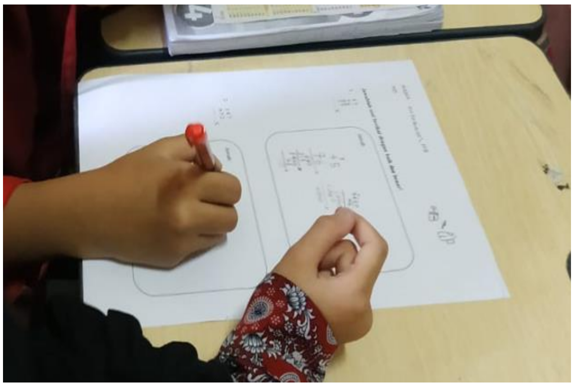

Figure 1. Student Activities Working on LKS

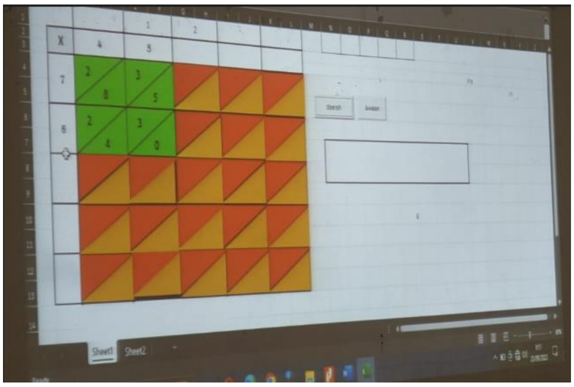

Figure 2. Media Based VBA for Excel

In the Figure 1 Visible student activities in group discussions during pretests. Students still find it difficult in multiplication of two or three numbers. There are some students confused about the placement of multiplication results that arrange down, they look confused when summing. Very few students answered correctly. In this two- or three-number multiplication material, students are expected to have memorized multiplications 1 to 10, so it will be faster in its completion.

After the implementation of the PBL model assisted by VBA-based Excel media, a posttest identical in structure to the pretest was administered to evaluate improvements in student learning outcomes. The difference between pretest and posttest scores was analyzed using the normalized gain (n-gain) formula as proposed by Meltzer (2002), which allows for a standardized measure of instructional impact by accounting for the maximum possible improvement. The calculation yielded a mean n-gain score of 0.9181, indicating a high level of improvement. According to the interpretation criteria provided by Meltzer, an n-gain score greater than 0.7 signifies that the intervention was highly effective in enhancing learning. This quantitative result was supported by a parallel measure: the n-gain effectiveness percentage, which recorded a mean of 91.8095%. According to Diana et al. (2018), an n-gain percentage above 76% corresponds to the "effective" category, affirming the pedagogical value of the intervention. These results demonstrate that the integration of the PBL model with Excel-VBA tools significantly improved student understanding of multiplication concepts. The visual and interactive nature of the digital media likely played a key role in helping students conceptualize multiplication as a structured process rather than a rote procedural task. In the Figure. 2, educators deliver learning using VBA for excel-based learning media presented using a projector. The learning media above is a naphier bone rod applied to technology. Naphier bone rods are made with programming language in VBA for excel which contains codings. This medium is very effective in helping students in solving the problem of multiplication of two or three numbers.

DOI: https://doi.org/10.29303/jipp.v10i2.3316

Figure 3. Example of Multiplication of 2 Numbers

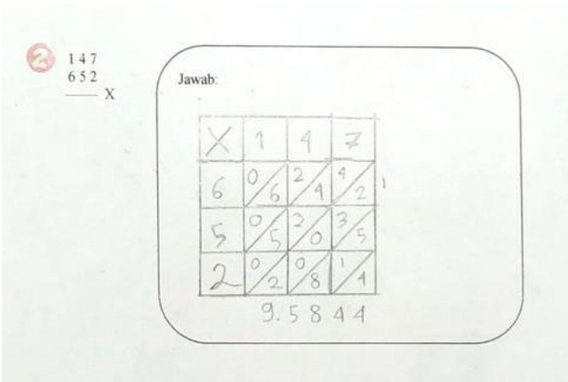

Figure 4. Sample Student Answer Results

In the Figure 3, you can see how to use the Naphier bone rod for multiplication of 2 numbers. The numbers in the blue row are multiplied by the numbers in the yellow column. On columns and rows pink color is the result of multiplication 8x4, 2x4, 8x5, 2x5. The number of the result of the multiplication is added up based on the diagonal. In Figure 4, an example of the results of student answers in solving using naphier bone rods. The above is the result of 147 x 652 multiplication, with the result being 9.5844. From this it can be seen that the child is able to complete the multiplication of three numbers so quickly and the results are correct. In this study, the improvement of learning outcomes related to students' comprehension ability and mathematical skills using a problem-based learning model with the help of VBA-based media for excel is presented in Table 5 below:

Table 5. Descriptive Statistics Results

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Ngain_Score	15	.80	1.00	.9181	.08880
Ngain_percent	15	80.00	100.00	91.8095	8.87994
Valid N (listwise)	15				

Based on Table 5 above, it shows that the n-gain score of the mean value is 0.9181. This mean value is greater than the criterion of 0.7 which means that the increase in student learning outcomes is high. For n-gain percent, the average value was 91.8095. This mean value is greater than the effectiveness criterion 76 which means that the level of effectiveness is effective. To evaluate students' affective responses to the instructional approach, a Likert-scale questionnaire consisting of ten items was administered following the intervention. The items addressed aspects such as clarity of instruction, enjoyment of the media, perceived usefulness of the digital tools, engagement during group work, and motivation to learn mathematics. The scoring followed the modified rubric and each student’s responses were converted into a percentage using the formula. The following student questionnaire results are presented in Table 6:

Table 6. Student Questionnaire Results

No.	Student	Number of Scores	Percentage
1	Student 1	36	90%
2	Student 2	39	97,5%
3	Student 3	34	85%
4	Student 4	34	85%
5	Student 5	35	87,5%
6	Student 6	35	87,5%

No.	Student	Number of Scores	Percentage
7	Student 7	33	82,5%
8	Student 8	34	85%
9	Student 9	35	87, 5%
10	Students 10	37	92,5%
11	Students 11	36	90%
12	Students 12	38	95%
13	Students 13	32	80%
14	Students 14	34	85%
15	Students 15	32	80%
Average			**87%**

Based on the results of the student questionnaire in Table 5 obtained an average percentage of 87.33%, meaning that students responded very positively to learning the VBA-based media PBL model for excel.

Discussion

The findings of this study indicated a significant improvement in student learning outcomes, as evidenced by the high average normalized gain (n-gain) score of 0.9181 and a corresponding effectiveness percentage of 91.81%. These results suggest that the use of the PBL model, when supported by Excel-based VBA media, substantially enhanced students' mathematical comprehension, particularly in performing multi-digit multiplication. These findings are consistent with previous studies which have shown that PBL contributes positively to students' ability to understand mathematical concepts through the application of real-world problems and collaborative learning (Fitriana & Nurhayati, 2024; Nafiah & Suyanto, 2014). In particular, Ward emphasized that PBL, by guiding students through scientific inquiry stages, promotes deeper cognitive engagement with mathematical content (Mareti & Hadiyanti, 2021). Similarly, Posamentier, Stepelman, and Kelly argue that PBL enables students to understand problems before engaging in their resolution, thus supporting meaningful learning (Meke et al., 2019).

The integration of VBA media further amplified this effect by offering visual and procedural scaffolding that reduced cognitive overload and supported structured problem-solving. As demonstrated in the study, students were better able to break down complex multiplication operations into manageable steps, facilitated by the interactive features of the Excel-based application. These results support Marcovitz's (2004) assertion that VBA enables object manipulation and functional customization that enhance the learning process within Microsoft Office applications. The digital media designed using Visual Basic for Applications (VBA) presented a novel pedagogical tool that bridged abstract numerical operations with visual representation. The VBA-based Napier bone rod, embedded in the Excel interface, allowed students to visualize partial products and their positions in the multiplication algorithm. This visual-spatial dimension played a crucial role in supporting learners with limited procedural fluency, particularly in identifying alignment and summation strategies across diagonals.

The findings are aligned with the work of Chotimah et al. (2018), who emphasized that the integration of technology in mathematics education supports the development of analytical and systematic thinking. By engaging students with dynamic and responsive digital tools, the learning process becomes more interactive and grounded in concrete experiences. Moreover, the interactivity offered by VBA programming enabled real-time feedback and experimentation, features that are associated with deeper learning engagement in digital learning environments. In the context of mathematical instruction, such media affordances have the potential to democratize access to higher-order cognitive processes by translating abstract operations into visual structures. The transformation of traditionally rote tasks into exploratory exercises empowers students to construct mathematical meaning through active manipulation and immediate reinforcement. The average student response score of 87.33% indicated a very positive attitude toward the integrated PBL and VBA-based instructional model. Students expressed high levels of satisfaction, enjoyment, and perceived learning gains from the use of the Excel-based media. These results affirm that students were not only cognitively engaged but also emotionally and socially motivated by the intervention.

Student testimonies and classroom observations reflected heightened enthusiasm during collaborative problem-solving sessions. The group-based PBL model, complemented by the novelty of the digital tool, created an environment that promoted teamwork, peer interaction, and shared ownership of learning tasks. This aligns with the argument by Glazer that PBL is inherently collaborative and cultivates communication and critical thinking skills in an authentic learning context (Nafiah & Suyanto, 2014). Furthermore, the results echo Anggara & Samsudin's (2023) findings that PBL enhances conceptual understanding and fosters a positive classroom climate. In the current study, the use of structured group activities through LKS (student worksheets) supported structured dialogue and division of cognitive tasks. As students assumed different roles within their teams—navigating the digital interface, interpreting results, and presenting solutions—they engaged in a distributed learning process that enriched the learning experience. One of the notable contributions of this study lies in its contextual relevance to non-formal education settings, specifically in equivalency education programs such as PKBM. Learners in such settings often exhibit diverse educational backgrounds, irregular attendance patterns, and limited prior exposure to technology-enhanced learning environments (Farlina et al., 2025; Safuri et al., 2022; Supiah et al., 2024; Susanto et al., 2025). Despite these challenges, the findings demonstrate that when properly facilitated, learners in alternative settings can benefit meaningfully from digital pedagogical innovations (Adiyono et al., 2025; Nurhayati, Dina, et al., 2024; Nurhayati, Hendrawati, et al., 2024; Nurhayati, Hermawan, et al., 2024; Nurhayati & Susanto, 2024; Rahmawan & Nurhayati, 2025).

The effective use of PBL in this context supports previous work by Sari (Hera & Sari, 2015), which emphasized the importance of cultivating logical reasoning and problem-solving abilities in mathematics instruction. The current study extended this principle by showing that digital tools can act as enablers of such reasoning processes, especially when integrated within a collaborative instructional framework. Moreover, this research responds to the call by the Indonesian Ministry of National Education for the development of innovative learning strategies that promote analytical, systematic, and critical thinking among students (Chotimah et al., 2018). By aligning instructional design with these national education priorities and leveraging accessible technologies like Excel, the study offers a replicable model for other community-based learning centers. This finding is particularly relevant in light of digital inequality and the limited availability of high-end educational technologies in marginalized communities (Ahmad et al., 2024; Nurhayati, Nurjaman, et al., 2024; Nurhayati & Kristiyanti, 2024; Nurhayati & Novianti, 2024; Suryani et al., 2025; Susanti & Nurhayati, 2024). The use of widely available software like Microsoft Excel, augmented with VBA, offers a cost-effective and scalable solution that can be adapted across varied contexts, including under-resourced learning environments.

While the results of this study are promising, several limitations must be acknowledged. First, the sample size was relatively small and context-specific, involving only 15 participants from a single community learning center. As such, the generalizability of the findings may be limited. Future research involving larger and more diverse populations, including formal school settings, would help validate and extend these results. Second, the study focused exclusively on multiplication material. It is unclear whether similar results would be achieved with other mathematical topics that require different cognitive strategies, such as geometry, fractions, or algebraic reasoning. Additional studies that apply the PBL-VBA model across multiple content domains would contribute to a more comprehensive understanding of its pedagogical utility. Third, while this study measured cognitive and affective outcomes, it did not include a control group or employ inferential statistical analyses to determine the magnitude of effect. Future studies using control-group comparisons and mixed-methods approaches may offer richer insights into the causal relationships and learning mechanisms involved.

CONCLUSION

This study set out to evaluate the effectiveness of integrating the Problem-Based Learning (PBL) model with VBA-based media for Microsoft Excel in enhancing students' mathematical comprehension, engagement, and attitudes within an equivalency education context. The findings revealed significant learning gains, with an average n-gain score of 0.9181, indicating a high level of improvement in students' ability to perform multi-digit multiplication. Students also reported very positive attitudes toward the learning experience, with an average satisfaction score of 87.33%, highlighting the motivational and cognitive benefits of the PBL-VBA integrated model. These outcomes underscore the importance of combining constructivist pedagogy with interactive digital tools to support meaningful learning, particularly in non-formal educational settings where learners often face diverse challenges. The VBA-based Excel media proved effective not only as a computational aid but also as a visual scaffold that facilitated deeper understanding of mathematical procedures. Moreover, the collaborative nature of the PBL approach encouraged peer interaction, critical thinking, and self-directed learning. This study contributes to the growing body of research on technology-enhanced learning in mathematics by offering empirical evidence of a low-cost, scalable, and contextually relevant innovation suitable for community-based education. It expands existing literature by demonstrating how mainstream tools like Excel, when appropriately adapted, can serve pedagogical purposes beyond administrative functions. Given the limitations of sample size and content scope, future research is recommended to replicate this model across broader mathematical topics and diverse learning populations. In addition, longitudinal studies may explore the long-term impact of such interventions on learner autonomy and retention. Overall, the study affirms that strategic integration of problem-based models with accessible technology has the potential to transform mathematics education and foster inclusive, high-impact learning experiences.

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