Contents lists available at Science-Gate

International Journal of Advanced and Applied Sciences

Journal homepage: http://www.science-gate.com/IJAAS.html

Impact of activity-based learning on understanding linear and quadratic functions: An evaluation of student performance and satisfaction in a Thai high school

Pissinee Thonhongsa [1], Suphawadi Srithammasatn [2], Apantee Poonputta [1,*]

[1]*Faculty of Education, Mahasarakham University, Mahasarakham 44000, Thailand*
[2]*Mathematics Learning Group, Kosum Wittayasan School, Mahasarakham 44140 Thailand*

ARTICLE INFO

Article history:
Received 26 January 2024
Received in revised form
26 May 2024
Accepted 2 June 2024

Keywords:
Activity-based learning
Linear and quadratic functions
Mathematical education
Student satisfaction
High school mathematics

ABSTRACT

Linear and quadratic functions are crucial topics in math education, and there is a significant focus on using activity-based learning (ABL) to teach these subjects. However, previous research has shown gaps, especially in how this approach affects high school students' learning outcomes. Most studies focus only on test scores and do not consider students' satisfaction or apply these methods to other math topics. This study aimed to assess the impact of ABL on the academic performance and satisfaction of 11th-grade students with linear and quadratic functions. The research was conducted in a Thai public school with 38 participants, using various tools like an ABL curriculum, skills assessments, achievement tests, and a satisfaction survey. The findings clearly showed that ABL improves students' understanding and problem-solving skills in complex math topics like linear and quadratic functions. This study provides solid evidence that ABL is effective in high school math, suggesting it could improve students' overall learning experiences and outcomes.

1. Introduction

Linear and quadratic functions are essential components of high school mathematical instruction. These fundamental mathematical notions are the foundational elements on which numerous related mathematical disciplines depend. Comprehending linear and quadratic functions not only provides students with crucial problem-solving abilities but also improves their general mathematical proficiency (Bowden, 2018). Proficiency in these areas is crucial for establishing a solid base for pursuing further education, particularly in sectors that provide lucrative degrees with high return on investment, such as engineering, economics, and sciences. Acquiring a deep understanding of linear and quadratic functions enables students to confidently approach increasingly advanced mathematical problems, paving the way for academic achievement and opening doors to future professional prospects (Abramowitz, 2014; McMullen, 2015).

It is crucial to recognize that linear functions and quadratic functions can be complex ideas in mathematics. Students must not only understand the fundamental principles but also be able to apply them in different problem-solving situations. The complexity of this subject stems from the requirement to comprehend the connections between variables, the importance of slope and intercepts, and the intricate characteristics of quadratic equations (Makonye, 2014). Therefore, it is not unexpected that numerous students face difficulties while trying to comprehend these basic principles (Trujillo et al., 2023). The complex characteristics of linear and quadratic functions require a focused and thorough approach to studying, which can often be challenging for pupils.

In Thailand's educational system, linear functions and quadratic functions are now part of the grade 11 curriculum. This curriculum covers various topics, including understanding basic concepts of linear equations, graphing linear functions, solving quadratic equations, and exploring the properties of parabolas. By the end of the course, students should be able to use these mathematical principles to solve real-world problems. However, many Thai students find these concepts challenging due to their

* Corresponding Author.
Email Address: oomsin.putta@gmail.com (A. Poonputta)
https://doi.org/10.21833/ijaas.2024.06.015
Corresponding author's ORCID profile:
https://orcid.org/0000-0001-6182-7333

complexity (Inprasitha, 2019). Thailand faces a pressing issue with students' mathematical skills, as demonstrated by past national test results where students' average scores have consistently fallen short, failing to reach even half of the maximum attainable score (NIETS, 2023). This predicament underscores the gravity of the situation and underscores the urgent need for attention and improvement in mathematics education.

Considering the content of Linear Functions and Quadratic Functions, an instructional approach that prioritizes active learning, the development of critical thinking skills, and collaboration holds the potential to address the challenges students often encounter with these intricate mathematical concepts. In this context, activity-based learning (ABL) emerges as a promising solution. ABL is an educational method that actively involves students in hands-on activities, problem-solving tasks, and collaborative exercises related to the subject matter (Başerer, 2020). This approach can benefit learners of Linear Functions and Quadratic Functions by promoting a deeper understanding of the material, enhancing problem-solving abilities, and encouraging real-world application of mathematical concepts (Vansdadiya et al., 2023). Additionally, it fosters student engagement, making the learning experience more motivating and relevant, ultimately equipping students with the skills needed to navigate the complexities of these mathematical functions effectively (Anwer, 2019).

Hence, in pursuit of an effective educational approach, this study has strategically embraced ABL as a core principle in the formulation of a robust learning management plan tailored to the specific needs of grade 11 students. Through active learning methodologies, this plan is designed to provide students with a dynamic and engaging platform for comprehending the intricacies of linear and quadratic functions. Through a meticulously designed curriculum that emphasizes hands-on activities, problem-solving tasks, and real-world applications, this approach aims to not only enhance students' understanding of these mathematical concepts but also cultivate their ability to apply them effectively. Moreover, by fostering an environment that encourages participation and teamwork, the plan seeks to motivate learners and establish a solid foundation for their future mathematical pursuits, ultimately addressing the existing challenges in mathematics education.

2. Literature review

ABL is an educational approach characterized by active and continuous student engagement in the learning process (Harfield et al., 2007). It fundamentally entails students actively participating in their learning experiences rather than serving as passive recipients of lectures. This approach distinguishes itself from traditional teaching methods by placing students in active roles and fostering collaboration within the learning environment. The core elements of ABL encompass active student involvement and collaborative interactions among peers, which collectively create a dynamic and positive learning atmosphere in the classroom (Fallon et al., 2013). ABL serves as a means to facilitate the construction of mental models, promote higher-order cognitive functions like applied problem-solving, and support the transfer of knowledge and skills. It encourages learning through practical engagement, discussions, problem-solving activities, and critical analysis, aligning with the belief that learning should be an active endeavor (Bonwell and Eison, 1991). In contrast to traditional teaching approaches, ABL ensures that both teachers and students play active roles in teaching and learning processes, promoting the discovery of mathematical concepts under teacher guidance ultimately resulting in enhanced retention and recall of concepts (Bonwell and Eison, 1991).

Scholars (Samaddar and Sikdar, 2023; Churchill, 2003; Chapaev et al., 2016) have presented the idea of ABL, and it seems to revolve around concepts such as active engagement, thinking skill development, collaboration, real-world problem-solving, and motivation. These principles serve as the cornerstones for creating a vibrant and effective learning environment tailored to the intricacies of linear functions and quadratic functions. In detail, active engagement stands as a linchpin of ABL (Churchill, 2003). Within the mathematical domain, this entails students' proactive involvement in a myriad of activities, discussions, and problem-solving tasks directly related to linear functions and quadratic functions. Coupled with active engagement is the principle of thinking skill development. ABL places a strong emphasis on cultivating critical thinking and problem-solving abilities (Chapaev et al., 2016). When applied to linear and quadratic functions, students are encouraged to analyze, synthesize, and evaluate mathematical concepts. They learn to dissect complex problems, break them down into manageable components, and derive solutions. In the collaborative spirit of collaboration, students are encouraged to work together in groups to tackle mathematical challenges and engage in meaningful discussions. While this principle certainly enhances mathematical understanding, it simultaneously nurtures effective communication and teamwork skills, attributes that are invaluable both in mathematical learning and in real-world applications. Another crucial aspect is the principle of real-world problem-solving. ABL in mathematics often integrates practical, real-life scenarios where linear and quadratic functions find practical application (Samaddar and Sikdar, 2023). Students are presented with authentic problems that require them to apply their mathematical knowledge in concrete situations. This not only renders the learning process more relevant but also equips students with the ability to employ mathematics in practical, real-world contexts. Lastly, motivation plays a pivotal role in ABL. Within the realm of mathematical education, the motivation stems from the dynamic and engaging nature of the learning process itself. As students witness the practical relevance of linear and quadratic functions and experience the satisfaction of successfully solving real problems, their intrinsic motivation to excel and thrive in the domain of mathematics is naturally ignited.

In the realm of mathematics education, a set of foundational principles guides the teaching and learning process, ensuring that it is both effective and meaningful. These principles are instrumental in shaping the pedagogical framework, with each one playing a pivotal role in enhancing mathematical understanding (Prediger et al., 2022).

Firstly, conceptual Focus lies at the heart of high-quality mathematics instruction. It underscores the importance of cultivating a profound grasp of mathematical concepts. Rather than rote memorization of procedures, this principle emphasizes the need to connect all mathematical operations to their underlying conceptual foundations (Hiebert and Carpenter, 1992). Through this approach, students not only acquire computational skills but also develop a deeper understanding of the mathematical principles at play. Rooted in the work of Henningsen and Stein (1997), cognitive demand in teaching mathematics advocates for engaging all students in higher-order thinking processes. This involves challenging students with complex cognitive tasks that foster critical thinking and problem-solving. By focusing on relevant knowledge elements, this principle elevates the intellectual rigor of mathematical instruction, encouraging students to think deeply and analytically. Moreover, quantitative empirical perspectives on instructional quality identify three key dimensions: classroom management, cognitive activation (which includes Cognitive Demand and Conceptual Focus), and student support (Prediger et al., 2022). This principle places a strong emphasis on tailoring instruction to individual students' needs, ensuring that all learners are actively engaged and receive the necessary support to thrive in their mathematical journey.

Long-term mathematical learning trajectories advocate for organizing subject-matter content in a coherent spiral curriculum. It ensures that mathematical concepts are introduced and reinforced progressively, allowing students to build upon their knowledge over time. This structured approach enhances retention and deepens understanding (Prediger et al., 2022). Finally, enhanced communication highlights the critical role of effective communication in mathematics education (Lampert and Cobb, 2003).

It can be seen that ABL aligns harmoniously with these principles of mathematics education. ABL promotes a deep conceptual focus by encouraging students to actively engage with mathematical concepts through hands-on activities and problem-solving, fostering a profound understanding beyond mere memorization. It complements the Principle of Cognitive Demand and Student Focus and Adaptivity by allowing educators to adapt activities to individual learning needs, ensuring active engagement for all. Scholars (Anwer, 2019; Apfler, 2023; Deringöl et al., 2021; Noreen et al., 2020; Noreen and Rana, 2019; Nwoke, 2021; Panarach, 2021) have conducted extensive research on the utilization of ABL in mathematics education. Notably, studies by Noreen et al. (2020) and Noreen and Rana (2019) revealed that students exposed to ABL outperformed their counterparts who received traditional teaching methods, signifying the effectiveness of ABL in enhancing mathematical learning outcomes. Additionally, research by Anwer (2019), Nwoke (2021), and Panarach (2021) emphasized the positive impact of ABL on high school students' mathematics learning, underscoring its suitability for older students. Moreover, Apfler (2023) identified the versatility of ABL, demonstrating its applicability to various forms of mathematics teaching, including distance education. Furthermore, Anwer (2019) and Deringöl et al. (2021) explored how ABL contributes to fostering positive attitudes among mathematics learners.

Therefore, the body of research suggests that ABL holds great promise as an effective approach to mathematics teaching. However, it is crucial to note the existing research gaps. Most previous studies have primarily focused on elementary school levels, with a noticeable lack of attention on high school education. This gap is significant, especially considering that high school students, even in their final stages, still require motivation to learn mathematics, particularly in regions like Thailand, where mathematical proficiency remains a challenge. Hence, there is a compelling need to explore the applicability of ABL in teaching specific mathematical concepts, such as linear and quadratic functions, at the high school level. Furthermore, it appears that previous studies have primarily concentrated on assessing mathematics learning outcomes, often measured through test scores, while tending to overlook the crucial aspect of developing mathematics processing skills, which are integral components of effective mathematical learning. This research seeks to bridge this gap by investigating the potential benefits of ABL in enhancing the understanding and engagement of Thai 11th graders with these mathematical topics, aiming to address critical educational challenges in the context of Thailand. The purposes of the study were to examine the effects of ABL management on grade 11 students' mathematics processing skills, to examine the effects of ABL management on grade 11 students' mathematics learning achievement of linear functions and quadratic functions, and to examine the student's satisfaction with the ABL management.

3. Methodology

The study employed a one-group experimental design, leveraging the principles of ABL to formulate a targeted learning management plan aimed at enhancing the comprehension of linear and quadratic functions among 11th-grade samples within the Thai educational context. The study's outcomes were assessed through a comparison of sample pretest and posttest performances, as well as their overall satisfaction with the instructional approach. The design of the study can be seen in Table 1.

Table 1: One-group pretest-posttest design

Experimental	Before	Between	After
One-group experimental design	Pretest	ABL	Posttest
Research instruments	Achievement test	Plan-mathematics processing skills assessment	Achievement test-satisfaction questionnaire

The study involved 38 participants from the 11th grade of a public school in Thailand, selected through purposive sampling. Several criteria guided their selection: Firstly, their enrollment in a public school in Thailand positioned them as representative of the broader Thai student population, shedding light on prevalent issues in Thai mathematics education. Secondly, they hailed from a province with a socio-economic and academic profile reflecting the median, making them a suitable representation of the majority of Thai students. Lastly, their placement in the 11th grade was pivotal since this is when the curriculum introduces the concepts of linear and quadratic functions.

The participation of these individuals was carried out with the utmost ethical consideration in human research. Confidentiality of their personal information was strictly upheld, and all research instrument questions were designed to avoid causing any harm to their emotions or well-being. These measures ensured the ethical treatment of the participants throughout the research process.

A learning management plan was crafted, drawing upon the principles of active learning management. This plan guided the design of activities that intricately aligned with the core principles of active engagement, thinking skill development, collaboration, real-world problem-solving, and motivation. For instance, students actively engaged in real-world problem-solving sessions where they collaborated with peers to tackle practical challenges directly related to linear and quadratic functions. These challenges ranged from analyzing the trajectory of a launched projectile (quadratic function) to calculating the growth of a savings account over time (linear function). This collaborative and activity-centered approach fostered critical thinking, teamwork, and a deeper understanding of linear and quadratic functions, making the learning process both interactive and engaging.

In summary, the learning management plan comprises seven distinct modules, each addressing specific aspects of mathematical concepts. These modules encompass the topics of linear functions, practical applications of linear functions, quadratic functions, the utilization of quadratic function graphs in equation-solving, and their role in addressing inequalities. Detailed descriptions of the corresponding activities are provided below to illustrate their practical application in teaching these topics and are shown in Table 2.

Table 2: ABL management plan

Lesson plans	Activities	Mathematics processing skills
Plans 1-2: Linear functions	Graph and equation	Mathematics communication and mathematical meaning
Plan 3: Practical applications of linear functions	Linear functions with sliders	Making connection
Plans 4-5: Quadratic functions	Hidden words	Problem solving
Plan 6: The utilization of quadratic function graphs in equation-solving	Take graph out	Problem solving
Plan 7: Quadratic function in addressing inequalities	Mathematics spot-the-error game	Problem solving

The learning management plan was evaluated by a panel of experts, including scholars in the field of education and experienced professional teachers. The results of the evaluation indicated that the learning management plan received an exceptionally high rating for its suitability, with an average score of 4.96.

After completing the activities in each lesson plan, a mathematics processing skills assessment was administered. This assessment included problem-solving tests and used a holistic rubric for scoring. The evaluation covered mathematics communication, mathematical meaning, making connections, and problem-solving. Experts who also evaluated the learning management plan reviewed the assessment. The results showed that both the questions and the scoring criteria were highly appropriate, with the highest level of adequacy ($\bar{x}$ = 4.92).

The test aimed to assess students' proficiency in linear and quadratic functions. It had two sections: one with 20 multiple-choice questions and another with two problem-solving questions, for a total score of 22. This test was used as both a pretest and a posttest to measure student progress. The content validity of the questions was evaluated using the IOC method, with values between 0.5 and 1.0. The questions had varying difficulty levels, ranging from 0.20 to 0.78 and discrimination values from 0.20 to 0.88. The reliability of the test, measured by the Lovett method, was 0.87.

The questionnaire was developed with the goal of evaluating students' satisfaction with the ABL management plan. It consists of three sections: demographic information, items for assessing satisfaction, and additional open-ended questions. Part 2 of the questionnaire contains ten satisfaction assessment items. The content validity of these items was determined using the IOC method, resulting in validity scores ranging from 0.67 to 1.00.

Assessments of mathematics processing skills were conducted after completing each lesson plan and analyzed using one-group t-tests, with 80% of the full mark as the criterion. Pretest and posttest evaluations of learning achievement in linear and quadratic functions were analyzed using paired-sample t-tests. Assessments were given at the end of the study to measure satisfaction levels and analyzed using descriptive statistics.

4. Results

4.1. The effects of ABL on Mathematics processing skills

The findings showed that students achieved an average score of 43.53 (SD = 4.06), which is higher than the expected threshold of 39.20 (80% of the full mark). This means that the average scores exceeded the 80% criteria for all assessments in each lesson plan. These results suggest that ABL effectively improved students' mathematics processing skills. Details of the results are provided in Table 3.

4.2. The effects of ABL on participants' learning achievement

The results show that all the data sets gathered in the current study were in a normal distribution. Both Shapiro-Wilk indicate no significant abnormality in data distribution in Table 4. Therefore, parametric statistics were employed to identify the results of the study.

It is worth noting that both the pre and post-test scores were assessed for normal distribution using the Shapiro-Wilk test. Consequently, a paired-sample t-test, a parametric statistical approach, was employed. The results in Table 5 underscore the positive impact of ABL on participants' learning achievements. The paired-samples t-test revealed a significant increase in the average posttest score ($\bar{x}$ = 20.34, SD = 2.31) compared to the pretest score ($\bar{x}$ = 5.11, SD = 2.19), with a t-value of 31.99 and p-value of 0.00. This interpretation suggests that participants notably enhanced their learning achievements in linear functions and quadratic functions through the utilization of a learning management plan designed with an ABL approach.

Table 3: The effects of ABL on Mathematics processing skills

Lesson plans	Mathematics processing skills	Full mark	Criteria (80%)	$\bar{x}$	SD	%
1: Linear functions	Mathematics communication and mathematical meaning	5	4.00	4.61	0.68	92.11
2: Linear functions	Mathematics communication and mathematical meaning	6	4.80	5.55	1.03	92.54
3: Practical applications of linear functions	Making connection	4	3.20	3.53	0.69	88.16
4: Quadratic functions	Problem solving	15	12.00	13.42	1.50	89.47
5: Quadratic functions	Problem solving	11	8.80	9.34	0.99	84.93
6: The utilization of quadratic function graphs in equation-solving	Problem solving	4	3.20	3.63	0.63	90.79
7: Quadratic function in addressing inequalities	Problem solving	4	3.20	3.45	0.72	86.18
	Overall	49	39.20	43.53	4.06	88.83

Table 4: Tests of normality

	Shapiro-Wilk		
	Statistic	df	p-value
Posttest	0.95	38	0.08
Pretest	0.96	38	0.15

p-value > .05: No significant abnormality in data distribution

4.3. Participants' satisfaction with the learning management plan

The results indicate that participants expressed a high level of satisfaction with the ABL approach. It is evident that students strongly agreed with the positive statements related to learning linear functions and quadratic functions within the ABL management plan ($\bar{x}$ = 4.32, 0.69). This interpretation suggests that ABL facilitated highly satisfactory learning experiences in mathematics education, particularly in the context of linear functions and quadratic functions (Table 6).

5. Discussion

The study's findings highlight the favorable outcomes achieved in mathematics classes, particularly in terms of students' enhanced mathematical processing skills, improved learning achievements, and increased satisfaction with the classroom environment. These results align with previous research conducted by scholars such as Anwer (2019), Apfler (2023), Deringöl et al. (2021), Noreen et al. (2020), Noreen and Rana (2019), Nwoke (2021), and Panarach (2021), who have also observed the benefits of ABL in mathematics education. This alignment can be attributed to the ABL approach, which employs a variety of activities to facilitate students' comprehension of mathematical concepts. In this study, students learned linear functions and quadratic functions through active learning, collaborative efforts, and real-world problem-solving, further emphasizing the effectiveness of the ABL approach.

In the realm of mathematical processing skills, it becomes evident that the ABL learning management plan effectively contributed to enhancing various facets of participants' mathematical abilities. These improvements include a deeper understanding of mathematical concepts and improved communication skills related to mathematics. Additionally, participants exhibited an increased ability to establish connections between various mathematical components and demonstrated enhanced problem-solving skills. This positive outcome can be attributed to the ABL approach, which afforded them ample opportunities to engage in critical thinking processes through real-world problem-solving tasks, a crucial aspect of mathematical learning. As suggested by Churchill (2003), ABL proves to be effective as it encourages learners to engage in systematic thinking processes.

Table 5: The comparison between students' pre and post-learning achievement tests

Learning achievement	n	Fullmark	x̄	SD	t	p-value
Posttest	38	25	20.34	2.31	31.99	.000*
Pretest	38	25	5.11	2.19		

*: p-value < 0.05

Table 6: Participants' satisfaction with the learning management plan

No.	Statements	x̄	SD	Degree of agreement
1	Engaging in learning activities has improved my understanding of the content	4.32	0.70	High
2	Participating in learning activities allows me to get hands-on experience	4.61	0.50	Very high
3	Learning through these activities makes me feel excited and enthusiastic	4.24	0.79	High
4	Engaging in learning activities gives me the freedom to think and express my ideas	4.26	0.76	High
5	These activities help me solve problems on my own	4.24	0.6	High
6	Collaborative learning activities promote mutual assistance among students during learning	4.53	0.69	Very high
7	Skill practice helps me understand linear functions and quadratic functions	4.42	0.60	High
8	I would like to do more of these skill practice exercises	4.13	0.62	High
9	I receive instant feedback on my performance	4.18	0.73	High
10	I feel happy when I learn through skill practice	4.26	0.79	High
	Overall	4.32	0.69	High

Moreover, students successfully attained the learning objectives related to linear functions and quadratic functions. Given the necessity for students to comprehend variable relationships, grasp the significance of slope and intercepts, and delve into the intricacies of functions (Bowden, 2018), ABL proved to be effective in providing them with the necessary knowledge and fostering a deep understanding of the subject matter. This success can be attributed to the active engagement, practical application, and collaborative learning elements inherent in the ABL approach.

Lastly, the study revealed that the participants had notably satisfying experiences with ABL learning management, a sentiment that resonates with the findings of Anwer (2019) and Deringöl et al. (2021), who also identified positive attitudes toward ABL in mathematics classes. This positive reception can be attributed to several key factors. Firstly, the ABL approach fosters active engagement, enabling students to take a more active role in their learning process. Secondly, it encourages collaborative learning, promoting interactions among students that enhance the overall learning experience. Additionally, ABL incorporates real-world problem-solving tasks, bridging the gap between theoretical knowledge and practical application. As a result, students not only gain a deeper understanding of mathematical concepts but also perceive the subject matter as more relevant and enjoyable. This overall satisfaction with ABL underscores its potential to transform mathematics education into an engaging and effective learning journey for students.

6. Conclusion

In conclusion, this study highlights the significant potential of ABL in the realm of mathematics education and addresses the gaps left by previous research endeavors. The study utilized ABL as a methodological approach to develop a comprehensive learning management plan aimed at teaching the concepts of linear functions and quadratic functions, subsequently assessing its impact on various learning outcomes, including mathematical processing skills, learning achievement, and student satisfaction with ABL. The results unequivocally demonstrate the manifold benefits of employing ABL in mathematics education, as it exhibited positive effects across all measured outcomes. This study contributes significantly to the field by providing empirical evidence supporting the efficacy of ABL in the high school context, particularly in teaching complex concepts such as linear functions and quadratic functions. Moreover, it underscores that ABL not only enhances students' conceptual knowledge but also cultivates their problem-solving skills in the context of linear functions and quadratic functions, enriching their mathematical proficiency.

While this study contributes valuable insights into the application of ABL in mathematics education, there remain several avenues for further exploration. Future research could delve deeper into the qualitative aspects of ABL, providing a more comprehensive understanding of students' perceptions, experiences, and the nuances of their learning journey. This qualitative data would offer valuable insights into the emotional and motivational aspects of ABL. Pedagogically, this study highlights the importance of incorporating ABL techniques into mathematics classrooms, particularly for teaching intricate mathematical concepts. Educators can benefit from the findings by considering the adoption of ABL strategies to promote active engagement, critical thinking, and collaborative problem-solving among their students.

It is important to acknowledge several limitations of this study. Firstly, the absence of a control group limits the ability to make direct comparisons and draw causal conclusions about the effectiveness of ABL. Secondly, the relatively small sample size may affect the generalizability of the findings to a larger population. Additionally, the lack of qualitative data restricts a comprehensive understanding of students' experiences with ABL, particularly in exploring the emotional and cognitive aspects. Future research could address these limitations by incorporating qualitative methods and larger sample sizes to provide a more robust assessment of the impact of ABL in mathematics education. Despite these constraints, the study still offers valuable insights into the benefits of ABL, laying the groundwork for further research and pedagogical advancements to enhance high school students' mathematical learning experiences.

Acknowledgment

This research project was financially supported by Mahasarakham University.

Compliance with ethical standards

Ethical considerations

Informed consent was obtained from all participants, ensuring confidentiality and adherence to ethical guidelines set by Mahasarakham University and Kosum Wittayasan School. The study was approved by the university's ethics committee.

Conflict of interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Abramowitz M (2014). Handbook of mathematical functions with formulas, graphs, and mathematical tables. Martino Publishing, Mansfield Centre, UK.

Anwer F (2019). Activity-based teaching, student motivation and academic achievement. Journal of Education and Educational Development, 6(1): 154-170. https://doi.org/10.22555/joeed.v6i1.1782

Apfler S (2023). The importance of activity-based learning for mastering mathematical tasks during distance learning in Austria. In: Ashraf MA and Tsegay SM (Eds.), STEM education—Recent trends and new advances, Intech Open. https://doi.org/10.5772/intechopen.113303

Baserer D (2020). Activity based teaching of concept types. World Journal of Education, 10(5): 122-130. https://doi.org/10.5430/wje.v10n5p122

Bonwell C and Eison JA (1991). Creating excitement in the classroom. George Washington University, School of Education and Human Development, Washington D.C., USA.

Bowden SA (2018). Introductory algebra: Linear and quadratic equations and functions. CreateSpace Independent Publishing Platform, Scotts Valley, USA.

Chapaev NK, Akimova OB, Selivanov AV, and Shaforostova TV (2016). The activity-based approach to achieving theoretical and practical consensus in pedagogy of NF Talyzina. International Journal of Environmental and Science Education, 11(16): 8821-8833.

Churchill D (2003). Effective design principles for activity-based learning: The crucial role of 'learning objects' in science and engineering education. Nanyang Technological University's National Institute of Education, Singapore, Singapore.

Deringöl Y, Ugurluel M, and Eren SB (2021). The effect of activity-based teaching approach on the attitudes of math-activities and their beliefs about mathematics of elementary school fourth graders. Acta Didactica Napocensia, 14(2): 284-298. https://doi.org/10.24193/adn.14.2.21

Fallon E, Walsh S, and Prendergast T (2013). An activity-based approach to the learning and teaching of research methods: Measuring student engagement and learning. Irish Journal of Academic Practice, 2(1): 2. https://doi.org/10.21427/D7Q72W

Harfield T, Panko M, Davies K, and Kenley R (2007). Toward a learning-styles profile of construction students: Results from New Zealand. International Journal of Construction Education and Research, 3(3): 143-158. https://doi.org/10.1080/15578770701715060

Henningsen M and Stein MK (1997). Mathematical tasks and student cognition: Classroom-based factors that support and inhibit high-level mathematical thinking and reasoning. Journal for Research in Mathematics Education, 28(5): 524-549. https://doi.org/10.5951/jresematheduc.28.5.0524

Hiebert J and Carpenter TP (1992). Learning and teaching with understanding. In: Grouws DA (Ed.), Handbook of research on mathematics teaching and learning. MacMillan, London, UK.

Inprasitha M (2019). A new model of mathematics curriculum and instruction system in Thailand. In: Vistro-Yu C and Toh T (Eds.), School mathematics curricula: Mathematics education – An Asian perspective: 51–77. Springer, Singapore, Singapore. https://doi.org/10.1007/978-981-13-6312-2_4

Lampert M and Cobb P (2003). Communication and language. In: Kilpatrick J and Shifter D (Eds.), A research companion to principles and standards for school mathematics: 237–249. National Council of Teachers of Mathematics, Reston, USA.

Makonye JP (2014). Teaching functions using a realistic mathematics education approach: A theoretical perspective. International Journal of Educational Sciences, 7(3): 653-662. https://doi.org/10.1080/09751122.2014.11890228

McMullen C (2015). Basic linear graphing skills practice workbook: Plotting points, straight lines, slope, Y-intercept and more. Zishka Publishing, Sacramento, USA.

NIETS (2023). NIETS data catalog. National Institution of Education Testing Service, Bangkok, Thailand.

Noreen R and Rana AMK (2019). Activity-based teaching versus traditional method of teaching in mathematics at elementary level. Bulletin of Education and Research, 41(2): 145-159.

Noreen R, Rafique S, and Perveen R (2020). Effects of activity-based teaching and traditional method of teaching mathematics in the area of knowledge at elementary level. International Journal of Management Research and Emerging Sciences, 10(3): 50-57. https://doi.org/10.56536/ijmres.v10i3.104

Nwoke BL (2021). Enhancing primary school pupils' mathematics creative ability through activity based learning approach. Malikussaleh Journal of Mathematics Learning (MJML), 4(2): 70-76. https://doi.org/10.29103/mjml.v4i2.5707

Panarach Y (2021). Development of mathematical learning model using activity-based learning. Turkish Journal of Computer and Mathematics Education (TURCOMAT), 12(8): 2712-2720.

Prediger S, Götze D, Holzäpfel L, Rösken-Winter B, and Selter C (2022). Five principles for high-quality mathematics teaching: Combining normative, epistemological, empirical, and pragmatic perspectives for specifying the content of professional development. Frontiers in Education, 7: 969212. https://doi.org/10.3389/feduc.2022.969212

Samaddar R and Sikdar DP (2023). Comparison between activity-based learning and traditional learning. GPH-International Journal of Educational Research, 6(10): 17-27.

Trujillo M, Atarés L, Canet MJ, and Pérez-Pascual MA (2023). Learning difficulties with the concept of function in maths: A literature review. Education Sciences, 13(5): 495. https://doi.org/10.3390/educsci13050495

Vansdadiya RP, Vasoya NH, and Gondaliya PR (2023). Beyond the classroom walls: Activity based learning for a real-world math experience. Asian Journal of Education and Social Studies, 43(1): 1-9. https://doi.org/10.9734/ajess/2023/v43i1930