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The potency of the adaptive cooperative learning model in strengthening numeracy performance of secondary school students: Education policy insights

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Abstract: The students' numeracy skills in Indonesia still need improvement. In order to strengthen numeracy skills for students, it is necessary to develop learning strategies that provide a fun and engaging learning environment for students by life involving the roles of parents, peers, and the community. This study aims to evaluate the effectiveness of the Adaptive Cooperative Learning model, developed by the researchers. Using a quasi-experimental design, the research involved a Cohort of around 32 students who participated in the product testing phase. The study incorporated a pretest, an experimental period, and a post-test. The findings revealed a marked improvement in student performance following the implementation of the Adaptive Cooperative Learning model, with the average score increasing to 79.44 and a standard deviation of 9.9. This equates to an N-gain of 0.77, which falls within the high range, suggesting that the model is effective in enhancing numeracy performance. The study concludes with several policy insights aimed at shaping future educational reforms in Indonesia, specifically in the area of numeracy teaching.

Keywords: *Adaptive Cooperative Learning model, Model effectivity, Numeracy performance, Policy insights.*

1. Introduction

In 2021, the Indonesian Ministry of Education, Culture, Research, and Technology issued a critical warning about Indonesian students' severe decline in numeracy skills [1]. Data from several sources support this alarming trend. Surveys from the Indonesia Family Life Survey (IFLS) for 2000, 2007, and 2014 reveal that adult respondents often struggle with basic numeracy, such as solving simple fraction problems. The 2018 PISA study highlights that students aged 15 underperformed in numeracy, with a stark socioeconomic gap in academic achievement between affluent and disadvantaged students [2]. Furthermore, Indonesia's performance in the Trends in International Mathematics and Science Study (TIMSS) 2011 assessment highlights a significant challenge in the country's educational system. Ranking 38th out of 42 participating countries and scoring below the "Low" international benchmark, these results underscore the need for comprehensive reforms in gravity of the situation [3]. This issue is further emphasized by a district-wide survey conducted by Maulana et al, which found that five out of six pupils were unable to perform basic mathematical tasks, such as single-digit addition[4].

One of the root causes of the above condition is that the learning process in educational institutions still neglects numeracy as a fundamental aspect of thinking [5]. The students are not accustomed to solving contextual, reasoning, and higher-order thinking Skills (HOTS) problems [6]. Additionally, the material taught often lack relevance to students' real-word experiences, reducing its meaningfulness. Aditionally, teachers' underdeveloped numeracy-based learning scenarios and insufficient familiarity with online learning media for numeracy classrooms contribute to the challenges in numeracy education [7].

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In response to these challenges, the Indonesian government has launched several strategic initiatives. The newly introduced emancipated curriculum is expected to have a profound impact on enhancing one of the fundamental skills-numeracy outcomes[8]. Furthermore, the government has placed a strong emphasize on improving numeracy teaching skills through extensive teacher training programs. These programs are meticulously designed to incorporate advanced pedagogical methodologies, integrate cutting-edge technological tools into mathematics instruction, and employ effective strategies to actively engage students in numeracy [9].

Additionally, national assessments, such as the National Student Assessment (Ujian Nasional), are employed to gauge students' numeracy proficiency, pinpoint areas needing further development, and guide policy decisions, ensuring that numeracy education aligns with national standards [10].

However, the constraints of the national curriculum often fall short of addressing the diverse needs of students or supporting a variety of instructional methodologies. Therefore, [11] suggests innovating models, methods, and media for numeracy instruction to be further developed by scholars. It is expected to help teachers be creative in developing learning materials that utilize adaptive media to meet students needs and align with contemporary educational demands. It is also supported by our preliminary study of 40 teachers from 40 schools across Indonesia (East-Mid-West areas), who shared that they are struggling to teach numeracy due to their lack of understanding of the effective model. It is common of this research that aims to offer teachers an effective numeracy model for classroom application. The study had explored and assessed the model developed by the researchers through direct experimentation, seeking to gain valuable insights into its effectiveness and impact. Last, the researchers provided some policy insights for the future policy in responding to numeracy conditions in Indonesia. Therefore, it is expected that this research can provide not only classroom implementation concepts, but also future recommendations for nationwide implementation.

1.1. Research Question

1. How effective is the adaptive-cooperative learning model in enhancing numeracy competencies among secondary school students?
2. What are policy insights based on the research results?

2. Theoretical Framework

2.1. Critical Needs of Numeracy Skills

Numeracy is a crucial skill set that encompasses understanding and applying numbers and mathematical concepts across a wide range of contexts, involving not only performing calculations but also interpreting data, analyzing patterns, and utilizing mathematical reasoning to tackle practical and real-world challenges. Mastery of numeracy extends beyond technical skills, significantly improving one's ability to analyze complex situations and solve intricate problems through its connection with critical thinking, thereby enabling individuals to address challenges with greater insight and precision and make well-informed decisions in various aspects of life [12]. This capability is crucial for making reasoned decisions and addressing multifaceted issues. Thus, it could be concluded that numeracy skills are crucial as they facilitate efficient management of daily tasks, improve problem-solving and decision-making abilities, contribute to academic and professional achievement, and promote informed engagement in societal matters. Therefore, numeracy becomes an essential skill to possess. In this research context, the researchers further explored and enhanced the student's understanding of mathematical concepts and their implementation in a specific mathematical topic through the implementation of our proposed model of Adaptive Cooperative Learning.

2.2. Adaptive Cooperative Learning Model

The Adaptive Cooperative Learning (hereafter: ACL) model integrates the concepts from Dick, Carey, and Carey, and Hannafin and Peck development models. This integration is based on the idea that before needs analysis, research and information collection should be conducted, as outlined in the Borg & Gall model. The Dick and Carey model is adopted for its detailed and effective development steps, which have proven successful in various educational contexts, from formal education to business

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training [13]. Moreover, the Hannafin & Peck model is included due to its simplicity and a strong emphasize on evaluation and revision at each stage. This approach aims to facilitate more rapid development of finalized teaching materials (adaptive content) through detailed evaluation and iterative revisions. The relevance of combining the Borg & Gall, Dick and Carey, and Hannafin & Peck models lies in their complementary strengths, providing a robust framework for developing an adaptive-cooperative learning model with varied teaching media.

The ACL model represents a sophisticated educational approach that merges adaptive learning principles with cooperative strategies and asset-based thinking, employing diverse learning media. This model encompasses a series of strategies and methods designed to be both flexible and adaptive, catering to differentiated learning needs through an asset-based perspective. It actively engages teachers, families, the broader environment, and peers to cultivate essential skills, such as communication, critical reflection, collaboration, and the ability to learn within a community of students.

The model's adaptability is evident in its application across content, process, and evaluation stages. Content adaptation is started with preparatory steps involving diagnostic assessments and learning style surveys (e.g., VARK test) to ascertain individual learning preferences. Analyzing these results facilitates the recommendation of suitable teaching materials, strategies, and supporting resources, all grounded in asset-based thinking. According to [14], the results of their study showed that the adaptive learning early warning intervention system provides information push for the students who need to intervene, combined with learning habits.

Process adaptation is facilitated through a blended learning approach that integrates both in-class and out-of-class activities tailored to meet the specific needs of students. This blended model incorporates Information and Communication Technology (ICT) in alignment with the available assets of students and schools, ensuring adaptability to the conditions of each educational setting. The approach also emphasizes the active involvement of classmates and family members to effectively address students' learning requirements. Evaluation adaptation is achieved by providing assessment tools in formats that align with students' learning styles, thereby enhancing their engagement and interest in the evaluation process.

The model synthesizes elements from cooperative, adaptive, and blended flipped classroom paradigms, incorporating collaboration, shared responsibility, social support, and a combination of online and offline learning modalities. It demonstrates flexibility, media diversification, and personalized learning grounded in asset-based thinking. This research focuses on teachers and students, with the developed learning media covering numeracy topics—in text, video, audio formats, and leveraging contemporary social media applications familiar for students and teachers. This recent meta-analysis study has estimated that ICT-based or -assisted mathematics learning has a moderate positive effect on the cultivation of students' numerical literacy.

2.3. ACL Syntax

The ACL model is an educational framework that intricately combines synchronous and asynchronous teaching strategies. It emphasizes the development of communication skills, collaboration, teamwork, and active participation in a learning community to create an engaging learning experience. The model aims to optimally achieve learning objectives through varied media tailored to students' needs.

The ACL model consists of two stages: preparation and learning implementation. Teachers assessed students' needs in the preparation stage and design tailored materials. The learning implementation stage focused on cooperative learning, where students worked in groups to solve problems and share knowledge. Continuous assessment ensured flexibility and effectiveness throughout both stages.

2.4. Preparation

The teacher selected assessment questions from a government platform called Merdeka Mengajar platform (hereafter: PMM) using the Student Assessment feature for initial assessment. This assessment was conducted online, with the teacher sending a link to students who complete it via the PMM app. The teacher also distributed a questionnaire about students' learning styles and needs to understand

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their preferences and requirements. The results of these assessments were then analyzed to formulate learning preferences and recommendations for the students.

2.5. Learning Implementation

Introduction

- Apperception and stimulus were provided using adaptive content for asynchronous study at home or outside the classroom.
- Students were grouped, each with one peer tutor (selected by the teacher based on the student's initial capabilities).

Core Activity I (asynchronous at home)

- Observation: Students independently studied the material (based on the preferred teaching materials) provided by the teacher, then summarized the material and submitted it to the teacher via email or WhatsApp.
- Elaboration: Students discussed their independent learning outcomes with their group, led by one student serving as a peer tutor. The peer tutor presented the assignment results discussed within the group. Other students listened and compared their work, with the peer tutor assisting those who need further clarification. Students then revised their assignments based on group feedback and resubmit them to the teacher.

Core Activity II (synchronous face-to-face at school)

- Collaborative Project: Students collaborated to consolidate their assignments based on group discussion feedback (e.g., in the form of a PowerPoint presentation, animation, flipchart, podcast, etc.) and work on any additional project assigned by the teacher. Groups then presented their work to other groups, with two representatives (the peer tutor and one group member) visiting each group sequentially. The visited group listens and reviews the presentation. This session developed communication and teamwork skills while building a learning community.

Closing (synchronous face-to-face at school)

- Reflection and Evaluation: The teacher conducted a reflection session involving student feedback, followed by an evaluation test (which could use interactive testing apps, such as Quizizz, Kahoot, etc.) to assess student understanding, along with numeracy questions on the Merdeka Mengajar platform.
- Affirmation: The teacher and students collectively affirmed the material learned. The teacher provided feedback on the group submissions and clarified any points that need correction or confirmation.

3. Method

3.1. Research Context and Method

This research is part of Research and Development (R&D) for a numeracy model. Gay mentioned that R&D evaluates theories in education and develops effective products for special school programs, such asteaching and learning materials and media[15]. This research is crucial for developing strategies that enhance numeracy competencies among students by improving teaching methods and strategies through the ACL model. This model aims to accommodate diverse learning styles and incorporate current trends in learning media and available ICT resources in schools, all in line with the asset-based thinking concept. As a result, numeracy instruction can become more effective, engaging, and flexible. The model is expected to improve students' numeracy skills, enabling them to better apply mathematical knowledge in real-life contexts. As a result, it is anticipated that this could lead to improve numeracy scores for Indonesian students, both nationally and internationally.

A quasi-experimental method was applied to measure the effectiveness of the model in this research context. According to [16], quasi-experimental research is a type of research design that aims to evaluate the effects of an intervention or treatment, which could be conducted with one group only [17]. Therefore, in this study, the experimentation used only one class stem, where the experiment was conducted with only one group (the experimental group) without a control group. This design, often

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called the one-group pretest-posttest design, measured the impact by comparing pretest results conducted before the intervention with posttest results.

Conducted after the intervention, the experimentation period was conducted from September to November 2023, with three learning sessions. The results would be measured based on pretest and posttest. The following display (1) presents how the experimentation process might take place.

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Display 1. Research Design

Pre-test	Treatment	Post-test
T	X	T

T_1 : Pre-test
X: Treatment by applying the ACL Model
T_2 : Post-test

3.2. Population and Sample

This study focused on the implementation of the ACL model to enhance numeracy skills, particularly on algebra, among seventh-grade students at SMP PGRI 1 Tangerang. Therefore, the population involved all the seventh-grade students enrolled at the school. The research respondents participated in product testing. The sampling method applied convenience sampling, which is a technique where samples were selected based on their easy accessibility, and no pattern applied [18]. Thus, the researchers used the sample as the teachers also suggested the students who might be in the sample list. Total number of respondents was 32 (thirty-two) students. Respondents participating in product testing were students engaged in the numeracy program on algebra for the 2023-2024 odd semester.

3.3. Data Collection

Data collection refers to the process of gathering information for both quantitative and qualitative inquiries to create a methodical approach to enhance efficiency in ensuring to achieve the research goal [19]. In this research context, multiple methods would be applied to collect the data as follows:

3.4. Observations

Observations were conducted to obtain a detailed picture of the learning process implementation at SMP PGRI 1 Tangerang, particularly in the seventh grade. The observations were participatory, with the researchers presented at each learning activity. This approach provided more accurate and detailed data on teacher and student behaviours, including formal and informal classroom interactions. Observations were repeated until the necessary data were obtained. The focus of the observations included the entire learning process, from planning and implementation to evaluating the outcomes of numeracy instruction on algebra for seventh-grade students. These observations were open-ended, allowing participants to freely express their views in response to general questions posed by the researcher. It is in line with Creswell that observation would allow the researchers to explore real-life conditions[21]. Three observations were conducted during the experimentation period.

3.5. Tests

Tests are frequently employed to assess attitudes, personality traits, self-perceptions, aptitudes, and the performance of participants [22]. In this research context, tests were done to examine the student's improvement before and after the experimentation. The tests conducted included pretests and posttests administered to students participating in the ACL model of instruction. The test items consisted of multiple-choice questions developed based on established guidelines aligned with the learning objectives from the teacher guidebook.

3.6. Data Analysis

The effectiveness of the ACL model was assessed to determine its impact. The evaluation of the developed product's effectiveness was based on the significance of the differences between the pretest

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and post-test results from field trials using a t-test. The scores from the pretest and posttest were then analyzed using a paired sample t-test to determine the significance of the differences between the pretest and posttest results. A prerequisite for conducting the paired t-test is first to perform a normality test. Once the data are confirmed to be normally distributed, the hypothesis testing is carried out using the paired sample t-test. The formula used for calculating the t-test mean is as follows [23]:

Following data processing of the pre-test and post-test results, statistical analysis was conducted using SPSS 25. Subsequently, the effectiveness of the developed learning product was then assessed using the normalized gain formula, as developed by Meltzer[24]:

Display 3 N-gain formula

$$\text{N} - \text{gain(g)} = \frac{\text{posttest score} - \text{pretest score}}{\text{ideal score} - \text{pretest score}}$$

To facilitate the interpretation of N-Gain calculations, the classification proposed by Hake (1999) was used as presented in the following table:

4. Result and Discussion

Research Question 1 : How effective is the adaptive-cooperative learning model in enhancing numeracy competencies among secondary school students?

The effectiveness test of the learning product was conducted to assess the effectiveness of the ACL model. The evaluation regarding the effectiveness of the developed product and learning activities can be measured by the significance of the difference between the pretest and post-test results during the field trial. Therefore, data from the pretest and posttest were processed and analyzed using Excel and SPSS version 25. The following presents the pretest and posttest results:

Based on the figure, the students' pre-test and post-test learning outcomes could be observed that the most of students' learning outcomes after participating in the numeracy learning activities on the algebra topic through the ACL model are higher.

Table 1:
Table of Mean Scores and Point Variation of Pre-Test and Post-Test Results

Indicator	Pretest		Posttest	
	Mean	SD	Mean	SD
Score	37	15. 25	74	21.42

Based on the table, it was found that the average student score before using the ACL model is lower at 37, with a point variation of 15.25. Meanwhile, after using the ACL model, the average student score is 74, with a variation of 21.42.

Next, a t-test was conducted to determine the significance of the improvement in learning outcomes between the pre-test and post-test. Before performing the t-test, a prerequisite normality test was required. The results of the normality test and the t-test are presented in Table 2 below:

Table 2:
Normality test of pre-test and post-test

One-Sample Kolmogorov-Smirnov Test			
		Pretest	Posttest
N		32	32
Normal Parameters	Mean	40.19	79.44
	Std. Deviation	10.551	9.929
Most Extreme Differences	Absolute	.127	.130
	Positive	.127	.089
	Negative	-.110	-.130
Test Statistic		.127	.130
Asymp. Sig. (2-tailed)		.200[c,d]	.184[c]

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The results presented in the table above indicate that the data are normally distributed, justifying the use of a paired sample t-test. The results of this analysis are summarized in the following table:

Table 3:
Results of the T-test on Pretest and Posttest Field Trial Outcomes

Paired Samples Correlations				
		N	Correlation	Sig.
Pair 1	Pretest & Posttest	32	.853	0.001
Paired Samples Test				
		T	Df	Sig. (2-tailed)
Pair 1	Pre-test-Post-test	-39.816	31	0.001

Based on Table 5 above, the t-test results show a significance value of sig = 0.001 < 0.05, indicating a statistically significant difference between students' average scores before and after using the ACL model.

Next, an N-gain analysis was performed using SPSS version 25 to assess the effectiveness of the learning model. The formula for calculating the N-Gain score can be seen as follows:
Display 4. N-Gain Formula

$$\text{N} - \text{gain(g)} = \frac{\text{posttest score} \; - \; \text{pretest score}}{\text{ideal score} \; - \; \text{pretest score}}$$

The effectiveness of the test was determined by calculating the N-Gain score and categorizing the N-Gain scores along with their interpretations.

Table 4:
Distribution of N-Gain Scores from Field Trial Based on SPSS Results.

Descriptive Statistics

	N	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
NGain_Score	32	0.46	0.88	0.7708	0.11814
NGain_Percentage	32	46	88	77.08	11.814
N Validity	32				

Table 5:
N-Gain Effectiveness Interpretation Categories

Percentage (%)	Interpretation
< 40	Not effective
40 – 55	Less effective
56 – 75	Moderately effective
> 76	Effective

Source: Hake 1999

Based on data presented in Tables 4 and 5, the N-Gain score of 0.77 indicates a moderately effective application of the ACL model for algebra numeracy at the secondary school level.

5. Discussion

The effectiveness of the learning product can be determined by implementing the ACL model in numeracy material at the secondary school level, as well as the results of pretests and posttests of the

students. Furthermore, to determine whether there is a significant difference between the average pretest and post-test scores, a statistical test (t-test) has also been conducted, as shown in Table 2. Before performing the paired sample t-test to examine the effectiveness of the ACL model, the researchers conducted a normality test as a prerequisite process. The results proved to be expected, allowing the t-test to proceed. Based on Table 2, it was found that the average score of students before using the ACL model in numeracy material at the secondary school level is lower at 40.19, with a point variation of 10.5.

Meanwhile, the average score of students after using the ACL model in numeracy material at the secondary school level is 79.44, with a point variation of 9.9. The t-test result showed a significance value of sig = 0.001 < 0.05, meaning there is a statistically significant difference between the average scores of students before and after the teachers' implementation of the ACL model. Statistically, this indicates a significant difference in the average numeracy scores on algebra topics before and after using the ACL model in secondary school numeracy material.

Furthermore, the average student learning outcomes increased, with the pretest average = 37 and the posttest average = 74, resulting in an N-gain of 0.77, categorized as moderate, meaning it is quite effective (as presented in Table 3). The posttest average score of 74 indicates a significant improvement in learning outcomes and student's ability to achieve the established competency standards. This shows that the ACL model in numeracy material at the secondary school level makes learning more effective.

Corroborated by the observation results, the researchers witnessed that the teacher presented the material in small units, starting with topics that were easier to understand and gradually moving to more complex topics, leading students to understand the material as a whole. The learning was conducted by accommodating students' learning styles and preferences for using ICT and optimizing communication and collaboration sessions among participants. The implementation of the ACL model made it easier for students to comprehend the material as it was designed according to their needs. The learning process more enjoyable by using the ACL website in the ACL model for numeracy material at the secondary school level, as it is easy to use and accessible anytime and anywhere. This is in line with what was stated by Kalz et al. that in today's era, technology is timely in improving the learning process[25]. The flipped classroom concept applied in the ACL learning model also influences learning process becoming more in-depth and flexible for students because they can repeat the material until they understand it. This is in line with the results of Kevser[26], which showed that the flipped classroom was more effective than the traditional method in terms of using deep learning strategies and increasing the levels of cognitive and emotional engagement.

Research results by Ghavifekr mention that integrating the use of ICT in education has a significant influence both for teachers and students[27], supported by good teacher preparation with ICT tools and facilities in achieving the success of technology-based teaching and learning. Miaomiao and Rui also mention that foreign adaptive learning research is more extensive and mature, but practical research focuses on higher education[28]. Besides,it is recommended to expand the scope of research in the future. The ACL model in secondary school numeracy materials encourages student independence, responsibility, and collaborative learning. Early evaluation data suggests that students are motivated and engaged by the ACL model, likely due to the adaptable content's flexibility for different learning styles and the emphasis on collaborative problem-solving aligned with higher-order thinking skills. This approach has the potential to strengthen students' numeracy skills. Its support by Ridwan et al., in the result of their study's meta-analysis, shows that cooperative learning improves numerics and mathematics learning outcomes for vocational high school students[29]. So the integration of the concept of adaptive and cooperative learning models into the ACL model can also combine the positive impacts of the two learning models.

Moreover, the learning process showed that the flow of learning becomes more flexible, dynamic, and engaging, no longer monotonous, rigid, and bored, making students more enthusiastic, eager, and focused on following the numeracy learning on the algebra topic until completion. Teachers became more innovative in preparing interesting learning materials (adaptive content), adaptive evaluation materials, as well as actively provided enrichment, reinforcement, and feedback on student learning outcomes using the ACL model in numeracy material at the secondary school level. The students

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responded very well and showed better learning outcomes when provided with immediate feedback on their learning results. This is undoubtedly a positive impact for students as the waiting time for learning results becomes shorter [30]. Students became more flexible in their learning, which could be done anywhere, anytime, especially using mobile learning. Although the ACL model in numeracy material at the secondary school level integrated ICT, social media, and mobile learning as media, the presence of teachers in the classroom still took place, further enhancing the effectiveness of the ACL model in numeracy material at the secondary school level. This is supported by the statement from Morgan that the presence of educators will also provide room for students to ask questions directly, seek clarification, and engage in discussions[31]. The use of ICT in mobile learning allows for broader learning, with the provision of the latest and accurate content [32], enhancing learning satisfaction[33][34], and improving learning experiences [35]. Mobile learning also makes learning more student-centered and facilitates academic success [36].

Based on the analysis of the ACL model's effectiveness in secondary school numeracy materials and the presentation of relevant research integrating ICT, mobile technology, and social media, it can be concluded that the ACL model is an effective learning model that can enhance students' numeracy learning outcomes.

5.1. Research Question 2. What are Policy Insights based on the Research Results?

Numeracy is a fundamental skills that should be possessed and placed at the heart of our education. However, our interactions with Indonesian teachers revealed challenges in teaching numeracy in classrooms. Most of the teachers have a limited understanding of numeracy, is often equating it solely with counting. Therefore, the heart of putting logical understanding into real-life perspectives from numeracy is missing. As a consequence, the teachers only focused on how they could deliver the materials in their textbooks only or from the prepared materials from the government[28]. They did not dig further to explore and contextualize their teaching into their context. During the research, the researchers therefore gained some policy insights for the government concerning numeracy in Indonesia. First, the government needs to improve the teachers' fundamental concepts regarding numeracy. It will be the basis for the teachers before teaching the students. Next, it is important to explore the diversity of the teachers and students to find the best teaching methods. Mostly, the government focuses on the national standard and has not given attention to the fact that the teachers and students are diverse. Last, it is important for the government to do large-scale research combining both qualitative and quantitative methods to gain many different effective methods for teaching numeracy. It will be useful for the teacher to have many references in teaching numeracy.

6. Conclusion

Employing a quasi-experimental method, the effectiveness of the ACL model in teaching numeracy at the secondary school level has been proven to enhance learning outcomes. Based on the t-test results using SPSS 25, the significance value (sig = 0.001) is less than 0.05, indicating a statistically significant difference between students' average scores before and after the ACL model was implemented. The statistical test revealed a significant increase in scores, with the average score before implementing the ACL model being 40.19 with a standard deviation of 10.55. The student's average score increased to 79.44, with a standard deviation of 9.9 after implementing the ACL model. This represents a gain of 0.77, which falls under the "high" category, meaning the model is effective.

The learning process through the ACL model for numeracy has become more effective, efficient, and enjoyable, as it can be done anytime and anywhere. Despite the ACL model integrates ICT, social media, and mobile learning, the presence of teachers in the classroom and collaborative sessions among student groups further enhance the effectiveness of numeracy learning.

Overall, the ACL model shows potential for improving numeracy performance and engagement. However,its long-term effectiveness, technology reliance,, and impact on diverse learners need further investigations to ensure equitable supports for all students. To address these concerns, the government should prioritize initiatives the deepen teachers' understanding of numeracy concepts, acknowledge the

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diversity of the teachers and students, and conduct more research in the area of effective models into effective numeracy teaching models.

6.1. Research Limitation and Future Research

The effectiveness of the model has only been tested in one class and has not yet been tried with both experimental and control groups. Future researchers should conduct experiments with both experimental and control groups to explore how they might give more insights when there are two different groups with different treatments.

The ACL model for numeracy at the secondary school level has been developed and tested with a single topic, namely algebra. It is important to support testing in different topics of numeracy, which aims to determine its effectiveness for different materials. Therefore, future research would be ideally to test the model on different topics.

The students' comprehension and performance were measured using only one aspect. The evaluation of learning outcomes was currently focused solely on cognitive domains, which aligned with the student's characteristics and learning objectives. Thus, future research can be essential to employ a socio-emotional evaluation to examine how the model might be effective in using different measurements to enrich the data and perspective. The results will be helpful for future model development.

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