



Development and Evaluation of "Acadi Math Made Easy" Board Game for Triangles and Quadrilaterals in Grade 4 Mathematics

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ABSTRACT

The low scores of the National Achievement Test and the Trends in Mathematics and Science Study in 2019 proved a setback for the Philippines' mathematics education. Researchers developed a board game to aid fourth graders in improving problem-solving abilities involving the perimeter of quadrilaterals and triangles. The study utilized a developmental research design. Mathematics experts implemented a rating sheet the Department of Education provided to evaluate the game using three categories (Content, Other Findings and Additional Requirements for Manipulative) with passing scores of 30, 16, and 18. The means from scores specified by the four raters were 36.75, 14, and 22. While these results clarified there is insufficient points to meet one criterion, the project remains implementable with indicated adjustments. Furthermore, a gap exists in studying the interactive game's effectiveness in teaching mathematics due to limited onsite sessions. The researchers suggest future studies address this gap. In conclusion, the Acadi board game is a potential instructional material for Grade 4 mathematics, enhancing problem-solving skills.

Keywords: educational board game, manipulative instructional materials, quadrilaterals, routine and non-routine problems

INTRODUCTION

Mathematics plays a significant role in developing human thoughts and systematic intellectual procedures used in problem-solving. It assists people in being able to foresee, plan, choose, and suitably resolve each problem in everyday life (Musso et al., 2019). In the Philippines, mathematics under the "K to 12 Education Program" intends to instill "critical and problem-solving skills" among Filipino learners. (Department of Education, 2013a). However, mathematics education in the Philippines has long been facing a dilemma. Before the "K to 12 Education Curriculum" was instituted in 2013, the results of the National Achievement Test (NAT), a standardized test administered annually by DepEd, revealed the struggle of many Filipino mathematics learners at both elementary and high school levels (DepEd, 2013a).

The NAT results in mathematics for the school year (SY) 2011-2012 showed that learners in grades 3 and 6 and 4th-year high school scored low with mean percentage scores of 59.87, 66.47, and 46.37. (The National Achievement Test in the Philippines, 2013b). These were lower than the DepEd's required mean percentage score of at least 75. Unfortunately, further data regarding the NAT math performances after SY 2011-2012 were unavailable online. In 2018, the country also participated in the Programme for International Student Assessment (PISA) for the first time, garnering a score of 353 points in Mathematics which is significantly lower than the Organization for Economic Co-operation and Development (OECD) average of 489 points and was categorized to be lower than level 1 proficiency (DepEd, 2019). Additionally,

the Philippines was absent from the countries participating in the Trends in Mathematics and Science Study (TIMSS) in 2015 (Mullis et al., 2016). In the 2019 TIMSS the country is ranked last with a score of 297. The average TIMSS Scale Center Point is 500, indicating that The Philippines is sub-par in Grade 4 Mathematics. These scores, relative to the other participating countries, are "significantly lower." (Ina et al., 2019). Consequently, there is a need to assess and overcome the difficulties of students when it comes to Mathematics and develop certain activities that will enhance the performance of the learners in a manner in which students will have the ability to comprehend the curriculum's covered concepts and practice their skills in problem-solving interactively (Jolejole-Caube et al., 2019). Grade 4 mathematics, under the K to 12 Basic Education Curriculum, states that learners must be able to illustrate core concepts and skills covering numbers and numbers sense, in particular, numbers from 1 to 1,000, as well as four critical operations, ordinal numbers, money bills up to PHP 100, and fractions. In geometry, learners are also expected to learn about shapes, symmetry, and tessellations. Algebra trends, statistics, and probability are also subject to lessons taught in grade 4 to develop the critical and problem-solving skills of the learners. (DepEd, 2013a).

Study shows that engagement in educational games has an apparent positive effect on learning. (Hamari et al., 2016). Educational games are functional in the

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learning technique for students as these games encourage students to participate in decision-making circumstances. Previous studies suggest that this approach also generates motivation and interactivity, particularly in subjects with low motivation for the learners. Learning games can improve students' high-level skills by establishing an appealing learning environment, making learning engaging, and allowing students to gain knowledge by doing. (Zeng et al., 2020). A combination of cognitive, motivational, affective, and sociocultural perspectives is necessary for game design research to fully capture what games offer to learn (Homer & Kinzer, 2016).

As such, this research aims to develop an educational kit entitled "*Solving routine and non-routine problems in real-life situations involving perimeter of squares and rectangles, triangles, parallelograms, and trapezoids*" in Grade 4 mathematics. Furthermore, this research also aims to assess the efficiency of educational games involving interactivity among students in learning mathematics, as well as to improve students' analytical thinking skills with difficulty learning mathematics.

The researchers used the list of least mastered topics provided by the Caloocan city school division office to establish the educational kit. This area was selected because past studies showed that students struggle with math story problems (Khoerunnisa, 2021). Moreover, factors such as learners not being accustomed to working on non-routine problems, being in a hurry to read and understand the questions, and spending less time in solving the problems given are the reasons why students commit reading, comprehension, transformation, process skill, and writing errors in solving problems involving triangular and quadrilateral data among students (Asriyani et al., 2020).

In today's science and technology, mathematics plays a crucial part. A better foundation for the students will help them learn more complex mathematics. Schools that apply the proposed approach will train students better.

For the researchers, the study will help uncover areas in the educational process that other researchers could not explore. The scope of the research is to provide an instructional kit for Grade 4 mathematics students on the topic of "*solving regular and non-routine issues in real-life settings involving the perimeter of squares and rectangles, triangles, parallelograms, and trapezoids.*" The study does not cover topics in Grade 4 Mathematics other than those stated above. The study is also limited in using four evaluators to assess the educational kit.

METHODOLOGY

Research Setting

The students at Caloocan City Science High School conducted the study. Due to the quarantine restrictions at the time of the research project, this research was executed remotely in each of the researchers' houses with the supervision of the research advisers (fourth and fifth authors).

Research Design

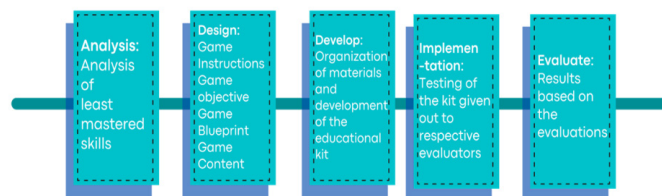


Figure 1. ADDIE Model

The study utilized a developmental research design. Developmental research has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet the criteria of internal consistency and effectiveness (Richey, 1994).

The ADDIE model was utilized to implement the study design. The analysis phase was used for the least mastered skills of grade 4 students in Mathematics. For the design phase, the game instructions, as well as its contents, were organized. The creation and development of materials of the educational kit were further administered. For the implementation, the kits were handed out to the evaluators to assess the materials, then the results were discussed in the evaluation phase. The statistical analysis that was used on the data gathered was descriptive analysis.

Gathering and Analysis of Data on Least Mastered Topics of Grade 4 Learners in Math

The researchers requested a copy of the least mastered topics of Grade 4 students in Mathematics from the Schools Division Office of Caloocan City. The least mastered skills were identified through a quick survey given to teachers and taken from the error frequency for the 3rd and 4th quarter periodical test result. The received copy was then compared to the learning competencies from the Most Essential Learning Competencies (MELCs) of DepEd to determine the topic that will be used for the educational board game. Among the topics, "*solving routine and non-routine problems in real-life situations involving perimeter of squares and rectangles, triangles, parallelograms, and trapezoids*" was selected for the development of the board game.

Design and Development of the Physical Kit

After analyzing the competencies and topics the grade 4 curriculum covered, the researchers developed the board game design and cards to be included in the Acadi Math Made Easy Board Game. Initially, a preliminary sketch was provided, demonstrating the plan for the design and layout of the manipulative, along with the mechanics of how the game can be played (Figure 2).

The problems in the cards were then formulated using sample problems from various worksheets and websites (Table 1) as guides. The layout of the board and cards was then done using Canva and Microsoft PowerPoint. The research advisers then checked the layouts and the content of the game.

After completing the revision and suggestions

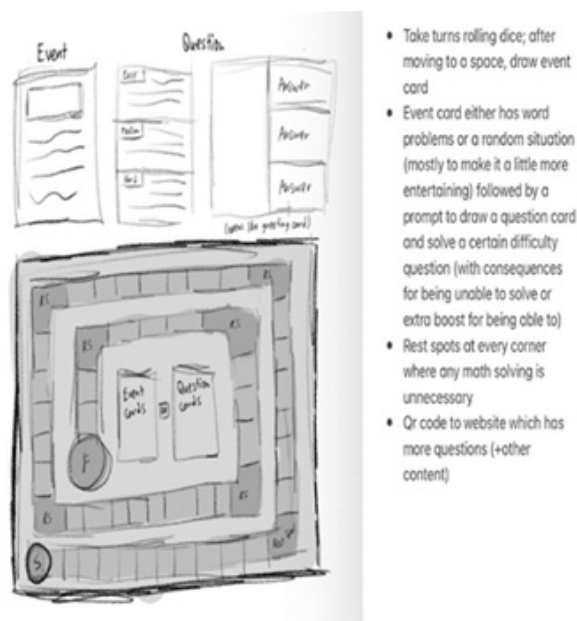


Figure 2. First draft of the board game

Table 1. Sample Problems used as guides in formulating the game cards

List of Sample Questions Written in Cards

1. When walking towards the bedroom, you notice the bed. You wanted to measure the bed before buying your sheets. After measuring, you found out that its length measures __ (roll the dice one time and add 70) inches, and its width measures__ (roll the dice one time and add 30) inches. What is its perimeter?
2. You decided to keep track of the distance that your mom walks when they cook in the kitchen. While cooking dinner, you counted that she walked around the kitchen a total of 5 times. If the kitchen measures__ (roll the dice and add 100) inches in length and __ (roll the dice and add 50) inches in width. What is the distance that she walked?
3. Your parents want to change the flooring of your playroom. The room has a length of __ (roll the dice, add 5, and multiply by 3) feet and a width of __ (roll the dice and multiply by 2) feet. What is the perimeter of the playroom floor?
4. You wanted to buy wood to make a picture frame for your photo. The picture is a __ (roll the dice and add 10)" by __ (roll the dice and 24)" rectangle. What is the total length of the wood strips you will need for your project?
5. A school project requires you to measure the perimeter of an object in your house. You decided to measure your television. After measuring, you found out that it measures __ (roll the dice and add 25) by __ (roll the dice and add 30) inches. What is the perimeter of the television?

Table 2. Worksheets and websites used as the basis for question formulation

List of Worksheets and Websites

Loudoun County Public Schools (n.d.). Unit 13 Homework: Area and Perimeter Word Problems [Homework Sheet]. Retrieved from <https://www.lcps.org>

Math-Aids.Com (n.d.). Dynamically Created Math Worksheets Retrieved from <https://www.math-aids.com/>

Education.com, Inc (n.d.). Perimeter Match [Worksheet]. Retrieved from <https://www.education.com/worksheet/article/perimeter-of-rectangle-2/>

Ask-math (n.d.). Perimeter of parallelogram. Retrieved from <https://www.ask-math.com/perimeter-of-parallelogram.html>

OnlineMathLearning.com (n.d.). Perimeter Word Problems: Examples from <https://www.onlinemath-learning.com/word-problems-perimeters-2.htm>



Figure 3. Final layout of the board game



Figure 4. Final layout of cards included in the game

made by the research advisers, the final layout of the board (Figure 3) shows a size of 15" by 15" printed on a Sintra board. The cards used in playing the board game were also printed. There are five event cards containing various instructions that players may draw and 25 question cards that the players are required to solve and compute to finish the game.

Furthermore, the gameplay of the board game was also finalized in this phase. The mechanics are as follows:

1. The Acadi board game is advised to be played by 2 or more players with 1 facilitator.
2. The board game represents an adventure with 30 steps. The player is required to draw a card for every step.
3. The question cards contain a word problem involving perimeters.
4. Read the instructions as a card is picked. Drawing a question card will require one to roll the dice to determine the values that will be used in solving.
5. Solve for the required values stated in the question

card.

6. For every correct answer, the player will take one step forward in the board until they reach the 30th step. When the answer is incorrect, it will be the other player's turn to pick a card.
7. Should there be a need for more cards, the players must shuffle the cards.

Gameplay

1. The game starts with three players. Player 1(P1) and Player 2(P2) as the players and Player 3(P3) as the arbiter.
2. The P3 will have to shuffle the cards in the game, will also be the one to check the values for each question, and will also be required to check the answers provided by the players.
3. To determine who will be the first, the players will each roll the dice, and whoever gets the lowest number will start first.
4. Assuming a dice roll and P1 gets the lower number, P1 starts the game.

Table 3. Mean scores in Content and its sub-categories

Sub-category	Evaluator				Mean	SD	Interpretation
	1	2	3	4			
1. Functional Suitability	4	4	3	4	3.75	0.500	Satisfactory
2. Material has the potential to arouse interest of the target users.	4	4	4	4	4.00	0.000	Very Satisfactory
3. Facts are accurate.	3	3	3	4	3.25	0.500	Satisfactory
4. Information provided is up to date.	4	4	3	4	3.75	0.500	Satisfactory
5. Visuals are relevant to the text.	3	4	3	4	3.50	0.577	Satisfactory
6. Visuals are suitable to the age level and interests of the target user.	3	4	4	4	4.00	0.000	Satisfactory
7. Visuals are clear and adequately convey the message of the subject or topic.	3	4	3	4	3.50	0.577	Very Satisfactory
8. Typographic layout/design facilitates understanding of concepts presented.	3	4	3	4	3.50	0.577	Satisfactory
9. Size of the material is appropriate for use in school.	4	4	3	3	3.50	0.577	Satisfactory
10. Material is easy to use and durable	4	4	4	4	4.00	0.000	Very Satisfactory
Sum:	36	39	33	39			Satisfactory
Mean of Sum:	36.75						
Overall Mean:	3.675						
Overall SD:	0.3808						

5. The player's starting point is the house. To proceed to the next number, P1 will have to draw a card from P3. If P1 gets an event card, P1 will have to follow the instructions mentioned, but if P1 obtains a question card P1 has to roll the dice, and P3 will have to check the designated values depending on the number of the dice rolled.
6. If P1 could answer the question, P1 moves forward to the next tile. If P1 fails to answer the question, P1 will stay in the same place, and P1's turn is done, and it is time for the next player, P2.

Factor B refers to other findings in the material, such as conceptual and typographical errors. The resource must have a score of 16 to pass the criterion. Failure to pass indicates that the resource needs additional revision based on the errors that were pointed out by the evaluators. Factor C refers to the overall design of the material. A high score indicates that the material promotes innovative pedagogy.

Statistical Analysis

Descriptive statistics were used by the researchers for the presentation of the data since the study is developmental research. The mean scores and standard deviations were computed for every sub-category, followed by the overall mean scores and standard deviations of the three categories. This statistical analysis was used to summarize and analyze the data that were collected. Furthermore, the researchers used an inter-rater reliability test to ensure that there was an agreement between the raters. The statistical test was performed with the help of SPSS, a free statistical data analysis tool.

RESULTS AND DISCUSSION

According to Table 3, *functional suitability* had a mean of 3.75 with a standard deviation of 0.5 which indicates that the material is suitable for its function. The sub-category pertaining to *the material having the potential to arouse the interest of the target users* had a mean of 4 and a Standard Deviation of 0, meaning that the material could arouse users' interests. The sub-category stating that *facts are accurate* had a mean of 3.25 and a

Evaluation of the Board Game

Four experts from the Math Departments of different schools evaluated the mathematical education board game to know if it would be suitable for grade 4 learners to provide aid to their learning style for mathematics. The educational board game was evaluated based on the Department of Education's Learning Resources Management and Development System standards. To achieve this, the instrument used in this study is the "Evaluation Rating Sheet for Charts, Posters, Drill / Flash Cards and Manipulatives" from the DepEd Guidelines and Processes for LRMS Assessment & Evaluation. The factors given in the evaluation sheet are as follows:

Factor A. Content refers to the concept and the layout of the material. The resource must score at least 30 points out of a maximum of 40 points. Failure to pass indicates that the contents of the material are inappropriate and/or the visuals were not suitable for the age levels of the targeted users.

Table 4. Mean scores in Other Findings and its sub-categories

Subcategory	Evaluator				Mean	SD	Interpretation
	1	2	3	4			
1. Conceptual errors.	4	3	3	4	3.5	0.577	Present but very minor & must be fixed
2. Factual errors	4	3	3	4	3.5	0.577	Present but very minor & must be fixed
3. Grammatical and/or typographical errors.	4	3	3	4	3.5	0.577	Present but very minor & must be fixed
4. Other errors (i.e., computational errors, obsolete information, errors in the visuals, etc.)	4	4	4	4	4.0		
Sum:	16	13	13	16		0.000	Not Present
Mean of the Sum:	14.5						
Overall Mean:	3.625						
Overall Standard Deviation:	0.43275						

standard deviation of 0.5, indicating that the material may have slight errors about the factual concepts in the problems. The *information provided, if it is up-to-date*, sub-category has a mean of 3.75 and a standard deviation of 0.5, meaning that the information is somewhat up to date. The relevance of the visuals to the text had a mean of 3.5 and a standard deviation of 0.577, indicating that the visual is relevant to the material's text. The sixth sub-category in Factor A had a mean of 4 and a standard deviation of 0, meaning that the material is user and child friendly. The *clarity and adequateness of conveying the message using the visuals* sub-category had a mean score of 3.5 and a standard deviation of 0.577, indicating that the visual's way of conveying the topics is somewhat clear.

Based on the evaluation results, it can be drawn that the developed board game covers the content that students need to study. This also implies that the developed board game is aligned with the selected most essential learning competency. Students enjoy the playful learning environment that board games offer, and they welcome board games as an entertaining way to learn. This is a significant result, especially for developing countries, as board games are inexpensive, interactive, and can make the students mentally and playfully active (Jordaan, 2018). Furthermore, games provide a fun, engaging, and challenging means of educating students at higher education institutions. (Hayhow et al., 2019).

Table 4 shows that the *conceptual errors* sub-category in Factor B showed a mean of 3.5 and a standard deviation of 0.577, indicating the need for revisions in some concepts in the material. The *factual errors* had a mean of 3.5 and a standard deviation of 0.577, indicating the need to check and revise for errors in the facts presented in the material.

The *grammatical and/or typographical errors* sub-category had a mean of 3.5 and a standard deviation of 0.577 indicating the need for editing in the grammar and the typography of the material. The fourth sub-category discusses the other errors presented in the material, With a mean score of 4 and a standard deviation of 0, the material showed no errors in the computational, obsolete

information, and others. Even though the overall mean score for this category was below the passing score, the evaluators gave a passing remark for the board game in this factor, provided that all necessary revisions in the manipulative will be accomplished. This implies that the developed board game will need only minimal revisions and can be used by teachers in teaching routine and non-routine problems in triangles and quadrilaterals.

Based on Table 5, sub-category 1 of Factor C indicates the presence of adequate support material with a mean score of 3.75 and a standard deviation of 0.5. It indicates that the manipulative has provided good support material. With a mean score of 3.5 and standard deviation of 0.577 in sub-category 2 of Factor C, the activities are summarized, and extension activities are provided. Sub-category 3 of Factor C, with a mean of 3.5 and standard deviation of 0.577, indicates the materials' support of innovative pedagogy. With a mean and standard deviation of 4 and 0, respectively, in sub-category 4, it shows that the manipulative is very safe to use. For sub-category 5, with a mean score of 3.75 and a standard deviation of 0.5, it indicates that the size and composition of the manipulative are suitable for the intended audience. With a mean of 3.5 and a standard deviation of 0.577 in sub-category 6, it indicates that the manipulative is compatible with the motor skills of the intended users.

Table 6 shows that the evaluators had an average score of 36.75 for the game's *content* which indicates a passing mark. Factor B, which refers to *other findings*, had an average score of 14 which indicates that the material requires specific revisions according to the errors pointed out by the evaluators. Factor C, the Additional Requirements for Manipulative, had a mean of 22 which indicates a passing mark. Given the interpretations based on the data gathered and the assessment accomplished by the evaluators, the Acadi Board Game was given the approval for possible use with the provision that necessary corrections and/or revisions will be made.

Table 7 presents the results of the inter-rater reliability analysis among the four raters. The Cronbach's Alpha score for the performed statistical test was = 0.80.

Table 5. Mean scores in Additional Requirements for Research Manipulative and its sub-categories

Subcategory	Evaluator				Mean	SD	Interpretation
	1	2	3	4			
1. Adequate support material is provided.	4	4	3	4	3.75	0.500	Satisfactory
2. Activities are summarized; extension activities are provided	4	3	3	4	3.5	0.577	Satisfactory
3. Suggested activities support innovative pedagogy.	3	4	3	4	3.5	0.577	Very Satisfactory
4. Manipulative is safe to use.	4	4	4	4	4	0.000	
5. The size and composition of the manipulative are appropriate for the intended audience.	4	4	4	3	3.75	0.500	Satisfactory
6. Suggested manual tasks within the activities are compatible within the motor skills of the intended users.	4	3	4	3	3.5	0.577	Satisfactory
Sum:	23	22	21	22			
Mean of the Sum:	22						
Overall Mean	3.667						
Overall SD:	0.455						

Table 6. Summary of mean scores for each category

	Mean	Standard Deviation	Interpretation
Factor A. Content	36.75	2.872	Passed
Factor B. Other Findings	14.00	2.449	Failed*
Factor C. Additional Requirements for Manipulative	22.00	0.816	Passed

* In defiance of the Other Findings category to have a mean of 14.00 that is regarded as failed, reviewers of the board game have accorded a *passed* remark through the evaluation sheets, hence the approval for the use of the manipulative for academic purposes.

Table 7. Reliability Statistics

Cronbach's Alpha	N of items
.80	20

An alpha value of = 0.80 is considered an excellent alpha value (University of Virginia, 2015), indicating that the questionnaire is very reliable.

Table 8 shows the item-total statistics of the inter-rater reliability. The perceived values scale, with 20 items, was subjected to a reliability examination. Cronbach's alpha revealed that the questionnaire was reliable, $\alpha = 0.80$. The majority of the items seemed worth keeping, resulting in a drop in alpha if they were eliminated. The only exceptions were items 19 and 20, which raised the alpha to $\alpha = 0.84$ and $\alpha = 0.85$, respectively. As a result, the removal of these items should be considered.

CONCLUSION AND RECOMMENDATION

Following the revisions needed for the board game and the data provided, the researchers established that the *Acadi* board game could be an aid in helping students improve their skills in solving routine and non-routine problems in triangles and quadrilaterals in grade 4 mathematics. The game also provides easy instructions, which aid young learners to play the game easily. The educational board game can be fixed without difficulty in case of error.

For future researchers who will conduct a similar study, it is recommended to test out the board game to

Table 8. Item-Total Statistics

Questions	Scale Variance if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Functional Suitability	69.50	15.00	.95	.75
Material has the potential to arouse the interest of the target users.	69.25	18.92	NaN	.80
Facts are accurate.	70.00	16.67	.49	.78
Information is up to date	69.50	15.00	.95	.75
Visuals are relevant to the text	69.75	16.25	.50	.78
Visuals are suitable to the age level and interest if the target users	69.25	18.92	NaN	.80
Visuals are clear and adequately convey the message of the subject or topic	69.75	16.25	0.50	.78
Typographic design facilitates understanding of concepts presented	69.75	16.25	0.50	.78
Size is appropriated to use for school	69.75	17.58	.21	.80
Material is easy to use and durable	69.25	18.92	NaN	.80
Conceptual error	69.75	15.58	.66	.77
Factual errors	69.75	15.58	.66	.77
Grammatical errors	69.75	15.58	.66	.77
Other errors	69.25	18.92	NaN	.80
Adequate support material is provided	69.50	15.00	.95	.75
Activities are summarized; extension activities are provided	69.75	15.58	.66	.77
Suggested activities support innovative pedagogy	69.75	16.25	.50	.78
Manipulative is safe to use	69.25	18.92	NaN	.80
The size and the composition of the manipulative are appropriate for the intended target audience	69.50	21.67	-.64	.84
Suggested manual tasks within the activities are compatible within the activities are compatible within the motor skills of the intended users	69.75	22.25	-.67	.85

the learners to see the effects of this development on their learning. It is also advised to increase the number of evaluators to validate the educational game further. In addition, the researchers also recommend trying a different topic used in the board game.

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