International Journal of Open-Access, Interdisciplinary & New Educational Discoveries of ETCOR Educational Research Center (iJOINED ETCOR)

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Contextualized Mathematical Learning Media in Fostering the Procedural Fluency Among Junior High School Students

Alner C. Abuso*[1], Allen E. Pasia[2]
[1] Dr. Maria D. Pastrana National High School, Division of Quezon, Philippines
[2] Laguna State Polytechnic University, Faculty of College of Graduate Studies and Applied Research
*Corresponding Author email: *alner.abuso@deped.gov.ph*

Received: 19 June 2023 **Revised**: 29 July 2023 **Accepted**: 08 August 2023

Available Online: 21 August 2023

Volume II (2023), Issue 3, P-ISSN – 2984-7567; E-ISSN - 2945-3577

Abstract

Aim: This study examined the impact of contextualized learning media on procedural fluency in mathematics education.
Methodology: This study used a quasi-experiment research design and was conducted at one of the public high school in Quezon with two different groups of respondents which are purposely selected with a total of 60 students, 30 students for each group. The validated pretest and posttest assessment were used to gather and determine the level of respondent in procedural fluency. This study lasted for four consecutive weeks within third quarter. The research focused on two groups of students exposed to different instructional sequences: the first group of respondents used the digital comics for the first two weeks then followed by interactive videos in the last two weeks as their learning media in which represent as the first sequence, while the other group was integrated to the second sequence, interactive videos to digital comics. The study analyzed pretest and posttest scores to evaluate the students' procedural fluency in terms of accuracy, flexibility, efficiency, and appropriateness. Additionally, student performance was compared based on their ability to provide correct answers, complete solutions, multiple strategies, and record their time while solving problems.
Results: The findings highlighted the importance of explicit instructions and guidance for students to ensure accurate evaluation of their procedural fluency skills. Furthermore, the study demonstrated the potential of contextualized learning media to enhance students' ability to apply multiple strategies, solve problems accurately and efficiently, and develop a deeper understanding of mathematical concepts.
Conclusion: In the first group, it was concluded that there was a significant difference in all components of procedural fluency of students before and after the exposure to the contextualized learning media. On the other hand, in the second group, it was concluded that there was a significant difference in all components of procedural fluency except flexibility of students before and after the exposure to the contextualized learning media. Moreover, in the first sequence of intervention, it was concluded that there was no significant difference in all components of procedural fluency of the students before the exposure in contextualized learning media. However, in the second sequence of intervention, it was concluded that there was a significant difference procedural fluency in terms of flexibility and efficiency of the students after the exposure in contextualized learning media.

Keywords: conceptualized learning media, procedural fluency, countered balance.

INTRODUCTION

In the past generation, students who had acquired basic knowledge of solving mathematical problems have gained conceptual understanding to recognize and generate solutions for the problems which helped them develop their procedural fluency skill (Al-Mutawah et al., 2019). Learning the fundamentals of procedural fluency was essential for the students to develop their mathematical understanding (Ho, 2020). This was necessary to

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

complement other aspects of mathematical skills, such as critical thinking and problem-solving skills, that helped the students find the right solution for the problem (Su, 2016).

The mathematical ability of the learners affected their procedural fluency (Inayah et al., 2020). This indicated that the learner's aptitude for mathematics predicts their ability to evaluate problems but due to difficulty of the subject matter alone, students failed to identify and find different ways of solving mathematical problems. Thus, the teachers must be responsible for innovative ways to improve the understanding of their students about the lesson. Effective teachers reformed their teaching strategies depending on the nature of the subject, phase of the courses, and other factors that may affect the learning process of the students. One of many strategies that may incorporate in teaching was utilization of educational learning media (Puspitarini & Hanif, 2019). These learning media assisted teachers to connect and engage their students in exploration of real-world experience and keep their classrooms actively engage in the learning process. Prior to this, the students developed a deeper understanding of the lesson that improved their performance.

Learning media can be traditional or innovative. The most used learning media was the traditional that focuses on text, audio, and visual representation of the material to convey information to the recipient which included print, radio, broadcast television, cable and satellites, and billboard (Ritakumari, 2019). These media stimulated a conducive interaction between students towards their teachers and peers. On the other hand,more innovative media with the use of advance technological mobile devices involved internet-based forms of promoting knowledge such as banners ads, social media, digital applications, and multimedia which allowed the students to be more flexible on their learning schedule (Demir & Akpinar, 2018). The advantageous of these advance learning media were, it allowed learners to acquire new knowledge and skills because of easily access through the internet from anywhere at any time as well as it offers teachers a wider choice of materials that can be certainly attached to their teaching process.

Having more advantages, innovative learning media outstand the timely and costly traditional learning media as source of delivering intelligence through the students. Connecting to the previous, most of the teachers used digital applications, and multimedia in the form of presenting their lesson (Marpanaji et al., 2018). In various classroom situations, these learning media were subject for academic modification which changed the way on how the students want to learn. Some examples of these modifications were lesser homework, easier activity, and contextualizing learning materials.

Contextualization of learning material was used in primary, secondary, and higher education to address content and activities that needed to be done in classroom which helped to connect students, develop content learning, and foster knowledge (Garin et al., 2017). Some methods of contextualizing the learning material were in terms of behavior, competency, time, or location. The teachers may contextualize the learning media in relation to localizing practices such as local issues and resources, traditional and cultural issues, and use of historical methodologies (Fernandes et al., 2020).

Procedural fluency was the ability to do procedures in a flexible, correct, efficient, and acceptable manner and to develop this ability, the students needed experience in integrating concepts and procedures and building on familiar practices as they created their own informal strategies and procedures (Foster, 2018). Thus, the researcher motivated to develop a contextualized learning media to enhance the procedural fluency in mathematics among junior high school students.

Research Questions

This research aimed to develop contextualized learning media in developing procedural fluency in mathematics. The study sought to answer the following questions:

1. What is the level of procedural fluency of a group of students before and after they are exposed in the first sequence (Digital Comics-Interactive Video) in terms of:
   1.1 Accuracy;
   1.2 Flexibility;
   1.3 Efficiency; and
   1.4 Appropriateness?
2. What is the level of procedural fluency of a group of students before and after they are exposed in the second sequence (Interactive Video-Digital Comics) in terms of:
   2.1 Accuracy;
   2.2 Flexibility;
   2.3 Efficiency; and

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ISSN
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

2.4 Appropriateness?

3. Is there a significant difference in the procedural fluency of students before and after the exposure when they are grouped according to the contextualized learning media used?
4. Is there a significant difference in the procedural fluency of the students according to the sequence employed after the exposure to the contextualized learning media?

Hypothesis

Given the stated research problem, the following hypotheses were tested on 0.05 level of significance:
Hypothesis 1: There is no significant difference in the procedural fluency of students before and after the exposure when they are grouped according to the contextualized learning media used.
Hypothesis 2: There is no significant difference in the procedural fluency of the students according to the sequence employed after the exposure to the contextualized learning media.

METHODS

Research Design

A quasi-experimental method of research is used in this study. This design included the two different groups of respondents. Both learning media, digital comics and interactive videos, were used in each group of respondents with the application of countered balance technique.

Population and Sampling

This study was conducted in one of the public high schools in Quezon within four weeks during Third Quarter of school year 2022-2023 in two groups of respondents with 30 students each group. Purposive sampling technique was employed.

Instrument

The researcher develop a modified tools to convey information and stimulate students' thoughts and attention in terms of contextualized learning media which specifically digital comics and interactive video. In this study, digital comics defined as a form of pictured learning media. It has a simple drawing and dialogue between characters that gives information about its content or stories. On the other hand Interactive Video is a type of multimedia that uses digital video that supports user to make decision and have sense of control over the videos. These videos play like regular videos, but it has a clickable area of selected hotspot. Moreover, the validated pretest and posttest assessment were used to gather and determine the level of respondent in procedural fluency as to accuracy, flexibility, efficiency, and appropriateness.

Data Collection

The data collection, examination, and analysis procedures were conducted in accordance with the study's objectives and research protocols. Firstly, a teacher-made test focusing on Geometry was developed to assess the procedural fluency of Grade 9 students. The test included questions that measured accuracy, flexibility, efficiency, and appropriateness in problem-solving. Before any interventions took place, a pretest was administered to all participants from both groups. The students responded to the test questions individually, and their answers were recorded. Following this, the intervention phase began, with one group using the first sequence and the other group using second sequence. The interventions aimed to provide contextualized learning experiences for the students.

During the intervention period, the students engaged in instructional activities and practice sessions using their assigned learning media. The interventions were designed to improve their procedural fluency by exposing them to various problem structures and scenarios. Once the interventions were completed, a posttest was administered to both groups. Moreover, the researchers collected the answer sheets of both the pretest and posttest from all participants. These answer sheets contained the students' responses to the test questions. The collected data were then carefully examined to ensure completeness and legibility. Any missing or unclear responses were addressed and resolved.

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Treatment of Data

In this study, the collected data underwent computerized computations for speed and accuracy. Frequency and percentage distribution will be utilized to analyze the students' responses and present the pre-test and post-test scores. To assess the significant difference in procedural fluency before and after the exposure, a paired t-test was employed when students were grouped based on the contextualized learning media used within each group. Additionally, an individual t-test was used to determine the significant difference between the sequences employed using contextualized learning media within the two groups.

Ethical Considarations

Throughout the entire process, the researcher diligently adhered to all ethical research protocols such as prioritizing of validity, reliability, and ethical soundness of the study to ensure the safeguard of well-being and interests of all individuals and organizations involved in the study.

RESULTS and DISCUSSION

Level of Procedural Fluency of Group of Students Before and After they exposed in Contextualized Learning Media

This section delves into the outcomes of the study, examines the relationships between variables, and explores the significance of the results in the context of the research objectives. It is within this section that the researchers critically analyze and synthesize the data, drawing meaningful conclusions and offering insights into the broader implications and applications of the study.

First Sequence Intervention (Digital Comics – Interactive Video)

This section comprehensively illustrates the scores of the students before and after the utilization of Contextualized Learning Media in Mathematical Lessons for Grade 9 focusing on Procedural Fluency in terms of Accuracy, Flexibility, Efficiency, and Appropriateness.

Table 1. Pretest Scores of First Sequence Group on Procedural Fluency

	Accuracy		Flexibility		Efficiency		Appropriateness		Level of Procedural Fluency
	f	%	f	%	f	%	f	%	
16-20	10	33.33	-	-	5	16.67	10	33.33	Exemplary
11-15	10	33.33	14	46.67	13	43.33	10	33.33	Proficient
6-10	10	33.33	16	53.33	12	40.00	10	33.33	Developing
1-5	-	-	-	-	-	-	-	-	Emerging
Total	30	100.00	30	100.00	30	100.00	30	100.00	

Legend: 1-5=Emerging, 6-10=Developing, 11-15=Proficient, 16-24=Exemplary

Table 1 showed the pretest scores of different respondent groups before instructional interventions. The results indicate that the respondents already had some understanding of Procedural Fluency, as they provided correct answers with complete solutions. This understanding can be attributed to their prior exposure to related mathematical concepts and procedures, which equipped them with the necessary knowledge and skills to approach problems accurately.

In terms of Flexibility, most students in the first sequence group scored at the Developing level, with fewer at the Proficient level. None reached the highest levels of flexibility. This suggested that students struggled to provide multiple strategies within a limited time frame while still getting the correct answers. The limited exposure to diverse problem-solving approaches and individual differences among students could have affected their flexibility. Some students naturally excelled, while others needed more guidance and practice. Additionally, efficiency was impacted by challenges in time management, problem comprehension, and procedural knowledge. Students who took longer or made errors faced difficulties in these areas, hindering their problem-solving abilities within the given time limit.

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ISSN
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Moreover, students in the first sequence group faced challenges in terms of flexibility and efficiency in their problem-solving abilities. They struggled to provide multiple strategies within a limited time frame and had difficulty managing time, comprehending problems, and applying procedural knowledge. This suggests that students may benefit from increased exposure to diverse problem-solving approaches, individualized guidance, and ample practice to improve their flexibility and efficiency. By providing instruction, practice, and exposure to various mathematical problems over time, students can acquire problem-solving strategies and develop a familiarity with problem-solving patterns, leading to improved procedural fluency and the ability to provide acceptable and complete solutions.

Furthermore, over time, students acquire problem-solving strategies through instruction, practice, and exposure to various mathematical problems. By encountering similar problem structures and scenarios, students develop a familiarity with problem-solving patterns, allowing them to recognize and apply appropriate procedures. This familiarity with problem types and their corresponding solutions contributed to their ability to provide acceptable and complete solutions (Elgrably and Leikin, 2021).

Table 2. Posttest Scores of First Sequence Group on Procedural Fluency

	Accuracy		**Flexibility**		**Efficiency**		**Appropriateness**		Level of Procedural Fluency
	f	%	f	%	f	%	f	%	
16-20	23	76.67	5	16.67	11	36.67	23	76.67	Exemplary
11-15	7	23.33	14	46.67	18	60.00	7	23.33	Proficient
6-10	-	-	11	36.67	1	3.33	-	-	Developing
1-5	-	-	-	0.00	-	0.00	-	-	Emerging
Total	30	100.00	30	100.00	30	100.00	30	100.00	

Legend: 1-5=Emerging, 6-10=Developing, 11-15=Proficient, 16-24=Exemplary

Table 2 displayed the posttest scores of respondents who used digital comics followed by interactive videos. The results showed that this instructional sequence improved accuracy and appropriateness in problem-solving. Many respondents achieved the highest level of performance, consistently providing correct answers with complete solutions. Prior knowledge and proficiency in mathematics influenced efficiency scores. The use of contextualized learning media in the third to fourth week positively impacted flexibility, with students automatically offering multiple solutions and employing different strategies. Overall, the intervention resulted in the majority of respondents achieving exemplary levels in accuracy, flexibility, and efficiency, indicating a strong understanding and improved problem-solving abilities. However, some students still needed further improvement in their efficiency.

After the implementation of the contextualized learning media during the second to fourth week, the students were able to answer the questions correctly with complete solutions even though the teacher did not explicitly instruct them to do so. During the early integration of the contextualized learning media, it helped students develop a better understanding of the problem-solving process and how to arrive at correct answer provided with complete solutions. This could have been facilitated by the media's ability to provide real-world examples and scenarios that allowed students to see how the concepts they learned were applied in practical situations (Dwijayani, 2019).

Second Sequence Intervention (Interactive Video – Digital Comics)

Table 3. Pretest Scores of Second Sequence Group on Procedural Fluency

	Accuracy		**Flexibility**		**Efficiency**		**Appropriateness**		Level of Procedural Fluency
	f	%	f	%	f	%	f	%	
16-20	9	30.00	4	13.33	20	66.67	8	26.67	Exemplary
11-15	12	40.00	16	53.33	8	26.67	13	43.33	Proficient
6-10	9	30.00	10	33.33	2	6.67	9	30.00	Developing
1-5	-	-	-	-	-	-	-	-	Emerging
Total	30	100.00	30	100.00	30	100.00	30	100.00	

Legend: 1-5=Emerging, 6-10=Developing, 11-15=Proficient, 16-24=Exemplary

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ISSN
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Table 3 revealed the pretest scores of respondents exposed to the second sequence (interactive video - digital comics) for Procedural Fluency. Surprisingly, even before the intervention, these respondents already displayed a solid understanding of the problems and provided correct answers, showcasing their impressive prior knowledge. Moreover, their remarkable flexibility in applying diverse strategies hinted at their untapped potential for further growth. The group's overall outstanding performance in solving problems swiftly and accurately underscored their remarkable efficiency. Nonetheless, the existence of variability within the group suggested an opportunity for even greater achievements. Notably, their excellent time-management skills, evident in their diligent recording of time, emphasized their exceptional ability to cultivate effective study habits.

In addition, the pretest examinations in the second sequence group showed that some students only provided one strategy leading to the correct procedure and answer, despite the explicit instructions in the assessment guidelines to solve the problems in many possible solutions. This result implies that these students have limited their ability to think creatively and critically when faced with complex problems, potentially hindering their performance in procedural fluency tasks due to the time constraints. They opt for the first method they think leads to the correct answer rather than taking the time to consider alternative approaches. The lack of flexibility in the students' problem-solving approaches also reflects a lack of exposure to varied and challenging mathematical tasks that require multiple strategies (Yu et al., 2015).

Table 4. Posttest Scores of Second Sequence Group on Procedural Fluency

	Accuracy		Flexibility		Efficiency		Appropriateness		Level of Procedural Fluency
	f	%	f	%	f	%	f	%	
16-20	28	93.33	10	33.33	25	83.33	28	93.33	Exemplary
11-15	2	6.67	17	56.67	5	16.67	2	6.67	Proficient
6-10	-	-	3	10.00	-	-	-	-	Developing
1-5	-	-	-	-	-	-	-	-	Emerging
Total	30	100.00	30	100.00	30	100.00	30	100.00	

Legend: 1-5=Emerging, 6-10=Developing, 11-15=Proficient, 16-24=Exemplary

Table 4 presented the posttest scores of respondents exposed to the second sequence (interactive video - digital comics) in terms of Procedural Fluency. The results indicated that the intervention was effective in improving the respondents' problem-solving abilities. They consistently provided correct answers and applied appropriate procedures, with a significant increase in the number of students achieving exemplary levels. The students also demonstrated flexibility by employing multiple strategies and approaches when solving problems. They were able to solve problems efficiently within an optimal timeframe, showcasing a strong understanding of concepts and effective application of procedures. Overall, the intervention positively impacted the students' problem-solving skills, leading to accurate solutions, efficient problem-solving, and a deeper understanding of mathematical concepts.

By consistently providing correct answers and applying appropriate procedures, students demonstrate a solid understanding of mathematical concepts and their effective application. The emphasis on multiple strategies and approaches of learning media allows students to develop flexibility in their problem-solving skills. This flexibility enables students to adapt their problem-solving strategies based on the specific problem context, effectively utilizing a range of techniques and approaches. These interventions often result in improved efficiency in problem-solving, as students become more proficient in selecting and executing appropriate strategies within an optimal timeframe. By engaging in problem-solving activities within the context, students develop a deeper understanding of mathematical concepts as they apply them to solve real-world problems (Astra et al., 2015).

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ISSN
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Test of Difference of Two Groups of Respondent in the Procedural Fluency of Respondent Before and After the Exposure on Contextualized Learning Media

Table 5. Test of Difference between Pretest and Posttest Score of First Sequence Group

	Test	M	SD	Mean Difference	t	df	Sig (2-tailed)
Accuracy	Pretest	12.40	3.54	4.80	-8.635	29	<.001
	Posttest	17.20	2.76				
Flexibility	Pretest	10.93	1.80	1.47	-2.75	29	0.010
	Posttest	12.40	2.94				
Efficiency	Pretest	11.73	3.10	2.93	-4.295	29	<.001
	Posttest	14.67	2.70				
Appropriateness	Pretest	12.60	3.72	4.60	-7.571	29	<.001
	Posttest	17.20	2.76				

if p ≤ .05 (significant); if p > .05 (not significant)

Table 5 presented the t-test results on the difference between pretest and posttest scores of the first sequence group, who were exposed to the intervention of Digital Comics - Interactive Video, in terms of Accuracy, Flexibility, Efficiency, and Appropriateness. The results indicated a significant improvement in all four components of procedural fluency after the intervention. There was a notable increase in accuracy and appropriateness, suggesting that the students' ability to provide correct answers with complete solutions improved significantly. The intervention using digital comics and interactive videos effectively supported their problem-solving skills. Additionally, the students showed improved flexibility, demonstrating the ability to discover different ways of solving problems. Their efficiency also increased, as they became more skilled at solving problems within a shorter time frame, thanks to the utilization of digital comics and interactive videos.

The t-test results supported the idea that the intervention of Digital Comics - Interactive Video had a positive impact on the first sequence group's procedural fluency skills. It enhanced their accuracy, flexibility, efficiency, and appropriateness in problem-solving. Customized math interventions that promoted automaticity in procedural tasks, as highlighted by Burns et al. (2015), were effective in improving students' performance. Digital technology, such as interactive and visually appealing content, can capture students' attention, increase their motivation and engagement, and facilitate a deeper understanding of mathematical procedures. This engagement led to improved problem-solving abilities, as students actively interacted with the content and explore different strategies and algorithms (Pepin et al., 2017). By leveraging digital tools, educators can enhance students' learning experiences and promote their procedural fluency skills.

Table 6. Test of Difference between Pretest and Posttest Score of Second Sequence Group

	Test	M	SD	Mean Difference	t	df	Sig (2-tailed)
Accuracy	Pretest	12.87	2.91	4.53	-7.999	29	<.001
	Posttest	17.40	2.11				
Flexibility	Pretest	12.00	2.97	2.00	-2.693	29	0.012
	Posttest	14.00	2.68				
Efficiency	Pretest	16.07	2.90	0.67	-0.97	29	0.340
	Posttest	16.73	1.78				
Appropriateness	Pretest	12.73	2.85	4.73	-8.286	29	<.001
	Posttest	17.47	2.16				

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ISSN
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

if p ≤ .05 (significant); if p > .05 (not significant)

Table 6 presented the t-test results for the second sequence group, who were exposed to the intervention of Interactive Video - Digital Comics, in terms of Accuracy, Flexibility, Efficiency, and Appropriateness. The results showed a significant improvement in accuracy, indicating that the interventions effectively enhanced the students' ability to solve mathematical problems correctly. The tailored approach and use of digital technology as a learning medium contributed to this improvement. The interventions also promoted flexibility, as students demonstrated the ability to apply multiple strategies and approaches when solving problems. However, there was no significant difference in efficiency, although students maintained a consistent level of efficiency throughout the intervention. Lastly, there was a significant improvement in appropriateness, indicating that students developed a better understanding of selecting appropriate strategies and methods for different types of problems.

The findings was aligned with the study of Rohaizata et al. (2020), which emphasized the positive impact of incorporating learning media in the classroom. Multimedia resources have revolutionized traditional teaching practices, providing students with innovative and interactive tools that inspire independent learning. In mathematics education, these resources have been shown to enhance understanding, promote flexible problem-solving strategies, and improve accuracy and precision in solving complex problems.

Test of Difference of Two Groups in the Procedural Fluency of Respondent according to the Sequence employed using the Contextualized Learning Media

Table 7. Test of Difference of Pretest Scores of the Two Groups of Respondents

	Intervention	M	SD	Mean Difference	t	df	Sig. (2-tailed)
Accuracy	Digital - Interactive	12.40	3.54	-0.47	-0.558	58	0.290
	Interactive - Digital	12.87	2.91				
Flexibility	Digital - Interactive	10.93	1.80	-1.07	-1.682	58	0.059
	Interactive - Digital	12.00	2.97				
Efficiency	Digital - Interactive	14.73	3.10	-4.33	-1.33	58	0.072
	Interactive - Digital	16.07	2.90				
Appropriateness	Digital - Interactive	12.60	3.72	-0.13	-0.156	58	0.438
	Interactive - Digital	12.73	2.85				

if p ≤ .05 (significant); if p > .05 (not significant)

Table 7 presented the t-test results comparing the pretest scores of the first sequence group (Digital Comics - Interactive Video) and the second sequence group (Interactive Video - Digital Comics) in terms of Accuracy, Flexibility, Efficiency, and Appropriateness. The results showed no significant differences between the two groups in terms of initial accuracy, flexibility, efficiency, or appropriateness in procedural fluency tasks. The composition of the groups, including variations in prior knowledge and individual capabilities, may have influenced the initial levels observed in the pretest scores, leading to non-significant results.

The remarkable heterogeneity observed within the groups indicated that students initially possessed varying levels of accuracy, flexibility, efficiency, and appropriateness. This inherent diversity in the composition of the groups may have acted as a confounding factor, potentially diminishing the observed differences between the two instructional sequences and yielding non-significant findings. It became evident that certain students naturally possessed higher levels of these crucial problem-solving skills, while others displayed more limited proficiency. This inherent variability among the students emphasized the need for personalized and tailored instructional approaches that address individual needs, allowing every student to reach their full potential.

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

The lack of significant differences in efficiency and appropriateness can be attributed to the presence of students with different learning styles and preferences. When teaching and problem-solving activities do not cater to these diverse preferences, it can hinder some students' ability to engage and solve problems quickly (Chotimah et al, 2018). Additionally, the results indicated that both groups had similar levels of procedural fluency before any interventions were implemented, challenging the assumption that different intervention methods automatically resulted in varying levels of proficiency.

Table 8. Test of Difference of Posttest Scores of the Two Groups of Respondents

	Intervention	M	SD	Mean Difference	t	df	Sig. (2-tailed)
Accuracy	Digital - Interactive	17.20	2.76	-0.20	-0.315	58	0.377
	Interactive - Digital	17.40	2.11				
Flexibility	Digital - Interactive	12.40	2.94	-1.60	-2.202	58	0.016
	Interactive - Digital	14.00	2.68				
Efficiency	Digital - Interactive	14.67	2.70	-2.07	-3.505	58	<.001
	Interactive - Digital	16.73	1.78				
Appropriateness	Digital - Interactive	17.20	2.76	-0.27	-0.417	58	0.339
	Interactive - Digital	17.47	2.16				

if $p \leq .05$ (significant); if $p > .05$ (not significant)

Table 8 presented the t-test results comparing the posttest scores of the first sequence group (Digital Comics - Interactive Video) and the second sequence group (Interactive Video - Digital Comics) in terms of Accuracy, Flexibility, Efficiency, and Appropriateness. The findings revealed that there were no significant differences in accuracy and appropriateness between the two groups. This suggested that the choice of sequence did not significantly impact the students' posttest scores in these aspects of procedural fluency. However, the composition of the groups, with variations in prior knowledge and individual capabilities, may have influenced the observed scores, minimizing the differences between the groups.

In terms of flexibility, there was a significant difference between the posttest scores of the two groups. The Digital Comics to Interactive Video sequence proved more effective in enhancing students' flexibility. Starting with Digital Comics provided visual representations and engaging narratives that helped students apply different strategies, fostering a deeper understanding of mathematical concepts. Transitioning from interactive videos to static comics proved challenging for students, hindering their flexibility in problem-solving. Interactive videos allowed active engagement and exploration of different approaches, while comics offered limited interactivity.

Regarding efficiency, there was a significant difference between the posttest scores of the two groups. Starting with Digital Comics as the initial intervention proved more effective in promoting efficiency in problem-solving tasks. The sequential and static format of comics encouraged students to approach problem-solving systematically, promoting critical thinking and logical connections. Following a clear sequence of steps led to improved solving techniques and faster completion of problems.

These findings supported the idea that interactive videos have the potential to foster procedural fluency by creating engaging and multi-sensory experiences. They offered choices, interactivity, and real-life simulations, increasing engagement and promoting problem-solving skills (Yu and Shi, 2020). Interactive videos facilitated the application of mathematical concepts in realistic scenarios, enhancing procedural fluency by encouraging flexible and efficient problem-solving. The potential for data collection on viewer behavior and engagement further contributed to optimizing content and improving learning outcomes (Jaouen and Robin, 2022).

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Summary, Conclusions, and Recommendations

This research examined the impact of contextualized learning media on procedural fluency in Grade 9 students. The study compared the pretest and posttest scores of two groups with different intervention sequences and assessed procedural fluency in terms of accuracy, flexibility, efficiency, and appropriateness. The research also analyzed if there were significant differences in procedural fluency based on the learning media and sequence employed.

The study's findings revealed significant differences in all components of procedural fluency for the first group sequence after exposure to contextualized learning media. However, in the second group, significant differences were observed in all components except flexibility. Additionally, the first sequence of intervention showed no significant difference in procedural fluency before exposure, accepting the null hypothesis. In contrast, the second sequence demonstrated significant differences in flexibility and efficiency after exposure, leading to the rejection of the null hypothesis specifically for these components.

It was recommended to the math teachers to consider incorporating contextualized learning media, such as digital comics and interactive videos, into their instruction to enhance students' procedural fluency. It is important for teachers to emphasize the development of flexibility in problem-solving strategies by providing varied practice and exposing students to diverse problem structures. Teachers should also consider the individual differences among students and provide additional guidance and practice to those who may need extra support. School heads can play a crucial role by encouraging the integration of contextualized learning media into the math curriculum and providing resources and support to teachers for effective implementation. Offering professional development opportunities for math teachers will further enhance their knowledge and skills in utilizing contextualized learning media for procedural fluency development. For future researchers, it is recommended to further investigate the impact of different types of contextualized learning media on procedural fluency across various grade levels and mathematical topics. Exploring additional factors such as student motivation, engagement, and metacognitive strategies can provide deeper insights. Longitudinal studies can also be conducted to examine the long-term effects of using contextualized learning media and its transferability to other mathematical contexts. These recommendations collectively aim to support math teachers, guide school leaders, and inspire future research in advancing procedural fluency through the effective use of contextualized learning media in mathematics education. Together, these efforts will promote improved procedural fluency in mathematics, empowering students for success in problem-solving and mathematical reasoning.

REFERENCES

Al-Mutawah, M. A., Thomas, R., Eid, A., Mahmoud, E. Y., & Fateel, M. J. (2019). Conceptual Understanding, Procedural Knowledge and Problem-Solving Skills in Mathematics: High School Graduates Work Analysis and Standpoints. *International journal of education and practice*, *7*(3), 258-273.

Astra, I. M., Nasbey, H., & Nugraha, A. (2015). Development of an android application in the form of a simulation lab as learning media for senior high school students. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(5), 1081-1088.

Burns, M. K., Walick, C., Simonson, G. R., Dominguez, L., Harelstad, L., Kincaid, A., & Nelson, G. S. (2015). Using a Conceptual Understanding and Procedural Fluency Heuristic to Target Math Interventions with Students in Early Elementary. *Learning Disabilities Research & Practice*, *30*(2), 52-60.

Chotimah, S., Bernard, M., & Wulandari, S. M. (2018). Contextual approach using VBA learning media to improve students' mathematical displacement and disposition ability. In *Journal of Physics: Conference Series* (Vol. 948, No. 1, p. 012025). IOP Publishing.

Demir, K., & Akpinar, E. (2018). The Effect of Mobile Learning Applications on Students' Academic Achievement and Attitudes toward Mobile Learning. *Malaysian Online Journal of Educational Technology*, *6*(2), 48-59.

Fernandes, J., Ponte, J., Matos, D., & Matos, J. (Eds.). (1992). *Mathematical Problem Solving and New Information Technologies: Research in Contexts of Practice: [proceedings of the NATO Advanced Research Workshop on*

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Advances in Mathematical Problem Solving Research, Held in Viana Do Castelo, Portugal, 27-30 April, 1991] (Vol. 89). Springer Science & Business Media.

Foster, C. (2018). Developing mathematical fluency: comparing exercises and rich tasks. *Educational Studies in Mathematics*, *97*(2), 121-141.

Garin, R., Reyes, R., Domantay, G., & Rosals, J. (2017). Contextualized and Localized teaching as a technique in teaching basic statistics. *Asia Pacific Journal of Education, Arts and Sciences*, *4*(1), 62-67.

Ho, T. M. P. (2020). Measuring conceptual understanding, procedural fluency and integrating procedural and conceptual knowledge in mathematical problem solving. *International Journal of Scientific Research and Management (IJSRM)*, *8*(05), 1334-1350.

Inayah, S., Septian, A., & Suwarman, R. F. (2020). Student procedural fluency in numerical method subjects. *Desimal: Jurnal Matematika*, *3*(1), 53-64.

Jaouen, L., & Robin, O. (2022). Explaining and teaching acoustics through comics, interactive web pages, and video games. *The Journal of the Acoustical Society of America*, *152*(2), 745-753.

Marpanaji, E., Mahali, M. I., & Putra, R. A. S. (2018, December). Survey on how to select and develop learning media conducted by teacher professional education participants. In *Journal of Physics: Conference Series* (Vol. 1140, No. 1, p. 012014). IOP Publishing.

Pepin, B., Choppin, J., Ruthven, K. *et al.* (2017) Digital curriculum resources in mathematics education: foundations for change. *ZDM Mathematics Education* 49, 645–661 (2017).

Puspitarini, Y. D., & Hanif, M. (2019). Using Learning Media to Increase Learning Motivation in Elementary School. *Anatolian Journal of Education*, *4*(2), 53-60

Ritakumari, S. (2019). Educational Media in Teaching Learning Process. *Bhartiyam International Journal of Education & Research*, *8*(3), 7-14..

Rohaizati, U., Mailizar, & Hajidin (2020). Junior secondary school teachers and students' needs for the use of digital comics in learning mathematics. *Journal of Physics: Conference Series, 1460.*

Su, H. F. H., Ricci, F. A., & Mnatsakanian, M. (2016). Mathematical teaching strategies: Pathways to critical thinking and metacognition. *International Journal of Research in Education and Science*, *2*(1), 190-200.

Yu, K. C., Fan, S. C., & Lin, K. Y. (2015). ENHANCING STUDENTS'PROBLEM-SOLVING SKILLS THROUGH CONTEXT-BASED LEARNING. *International Journal of Science and Mathematics Education*, *13*, 1377-1401.

Yu, X., & Shi, L. (2018, December). A Comparative Research on Cognitive Effect of Infographic and Animation Presentation in News. In *2018 International Joint Conference on Information, Media and Engineering (ICIME)* (pp. 73-76). IEEE.

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

APPENDICES

Pre-test

Name: _____ Scores:_____

Direction: Solve the following question with as many solutions as you can use. Show your complete solutions. Use the guide questions below in answering each problem. Don't forget to record your time while answering each number.

1. One of the well-known pharmacies in Mauban Quezon is Maureen Pharmacy. It has a parallelogram shaped storefront signage. Let ABCD is the name of parallelogram in which ∠A = 75°. Find the measure of each of the angles ∠B, ∠C, and ∠D.

Time Started: _____ Time Ended: _____

Solution #1

Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

2. A statue commemorating Gat Uban, a local hero who fought against Moro pirates that once invaded the town of Mauban in the late 17th century. Assume that the shape of platform in the picture below is a parallelogram. The parallelogram is named EFGH. The perimeter of the parallelogram is 30 units, and the length of the side $\overline{EF}$ is 9 units. Find the length of the side $\overline{FG}$.

Time Started: _____ Time Ended: _____

Solution #1

Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

3. "O' Cup – Mauban" is one of the famous cafe shops in Mauban. Their milk tea machine can produce 1 large milk tea in 3 minutes. Pedro with his friends wants to buy a 6 large milk tea. How long does it take for a machine to finish their order?

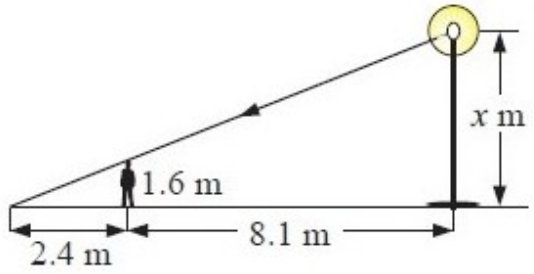
Time Started: _____ Time Ended: _____

Solution #1

Time Started: _____ Time Ended: _____

Solution #2

4. A "barangay tanod" who is 1.6m tall roams around the vicinity of Gazebo Plaza in Brgy. Sadsaran. He casts a 2.4m shadow when he stands 8.1m from the base of an electric light pole. How high above the ground is the light globe?



Time Started: _____ Time Ended: _____

Solution #1

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

Time Started: _____ Time Ended: _____

Solution #2

Post-test

Name: _____ Scores:_____

Direction: Solve the following question with as many solutions as you can use. Show your complete solutions. Use the guide questions below in answering each problem. Don't forget to record your time while answering each number.

1. A pay parking lot is constructed near Mauban Port for tourists of Aquazul Beach Resort in the shape of a parallelogram. Let GHIJ be the name of parallelogram. The side $\overline{GJ}$ is 5x while side $\overline{HI}$ is x + 44. Find the lengths of the sides $\overline{GJ}$ and $\overline{HI}$.

Time Started: _____ Time Ended: _____

Solution #1

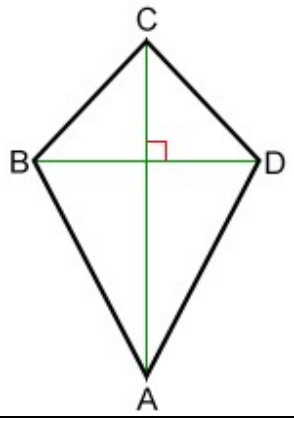
Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

2. Juan, a SK Chairman in Brgy. Bagong-Bayan, organized a KITE FLYING COMPETITION during the celebration of MAUBANOG FESTIVAL. You are invited to be one of the competitors. You designed the kite with two diagonal lengths 46cm and 78 cm. If you want to know the area of needed paper for the kite, how wide should the dimension of paper be?



Time Started: _____ Time Ended: _____

Solution #1

Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
ETCOR REVIEW CENTER
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

3. A cyclist wants to travel to Butas-Butas Beach in Brgy. Cagsiay II, Mauban, Quezon which 15km far with constant speed. His bike can travel 20km in an hour. How long does it take for him to finish the ride?

Time Started: _____ Time Ended: _____

Solution #1

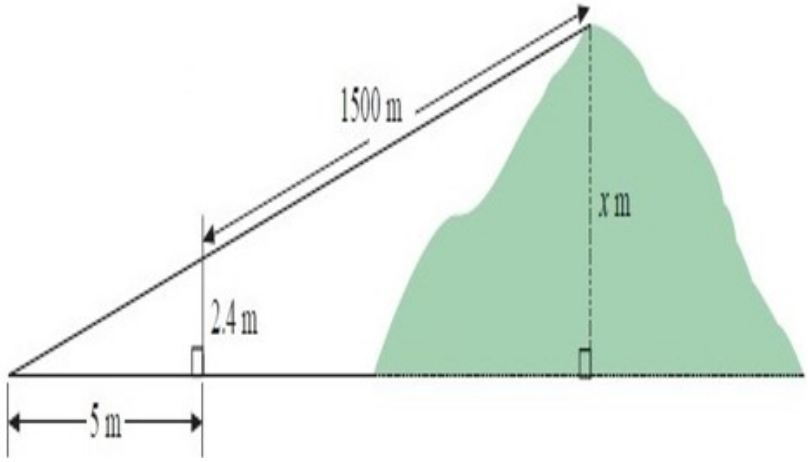
Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035

ETCOR Educational Research Center PHILIPPINES
Sta. Ana, Pampanga, Philippines
INTERNATIONAL MULTIDISCIPLINARY RESEARCH CONFERENCE
Google Website: https://etcor.org
NBDB NATIONAL BOOK DEVELOPMENT BOARD PHILIPPINES
iJOINED ETCOR
P - ISSN 2984-7567
E - ISSN 2945-3577
ETCOR REVIEW CENTER
The Exigency
P - ISSN 2984-7842
E - ISSN 1908-3181

4. Two surveyors estimate the height of Rizal Park Hill in Brgy. Rizalina. One stands 5 m away from the other on horizontal ground holding a 3 m stick vertically. The other surveyor finds a "line of sight" to the top of the hill, and observes this line passes the vertical stick at 2.4 m. They measure the distance from the stick to the top of the hill to be 1500 m using laser equipment. How high, correct to the nearest meter, is their estimate of the height of the hill?



Time Started: _____ Time Ended: _____

Solution #1

Time Started: _____ Time Ended: _____

Solution #2

ETCOR's Website : https://etcor.org
Facebook Page : https://www.facebook.com/EmbracingTheCultureOfResearch
Twitter Account : https://twitter.com/ETCOR_research
YouTube Channel : https://tinyurl.com/YouTubeETCOR
E-mail Address : embracingthecultureofresearch@etcor.org
Mobile Number : 0939-202-9035