

Development and Acceptability of Worktext in Differential Calculus Among Students of University of Rizal System

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Article History:

Received: 27-10-2024

Revised: 23-11-2024

Accepted: 03-12-2024

Abstract:

There has been an increased emphasis on students to recognize significance of Calculus in many areas of life. Hence, the demand of instructional materials like worktext despite rapid development of new technologies continues. This research is focused on developing a worktext that enhance students' solving ability, improving academic performance and creative thinking towards teaching material for this course. It is based on the outline prescribed by the Commission on Higher Education Memorandum Order (CMO) No. 12, series of 2008 (CHED, 2008). Developmental method of research was employed, and it utilized the ADDIE model (Analysis, Design, Develop, Implement, and Evaluate) to develop the instrument of instruction. Mathematics experts determined its acceptability using a validated evaluation instrument. Results showed that the worktext is acceptable in terms of content, relevance' style and presentation, usefulness, and clarity using weighted mean. Furthermore, the performance of students using the worktext reflected a significant difference compared to those who did not use. Thus, it validates the successful development and integration of the worktext into the course.

Mathematics teachers and professors are hereby recommended to develop and design their supplementary materials for their students to develop and enhance their mathematics performance.

Keywords: acceptability, worktext, development, differential calculus, ADDIE model

Introduction

Mathematics, as a fundamental discipline, plays a crucial role in various academic fields and is an essential component of any educational curriculum. Among its branches, calculus stands out as one of the cornerstones of mathematical knowledge, providing valuable tools for analyzing change and solving complex problems. Differential calculus is a necessity and of highly important as it serves as a vital foundation for many scientific and engineering disciplines. It provides a basis for understanding mathematical concepts and helps a person develop practical scientific and engineering sense and problem-solving skills. In a sense, calculus is a form of communication about the world just as much as language is a form of communication about thought.

The University of Rizal System, a prominent institution of higher education known for its commitment to academic and service excellence, recognizes the significance of shaping students' analytical and problem-solving skills. To enhance the learning experience of its students, faculty are encouraged to use instruction suited to the level of understanding of students. Current instructional materials should be employed as tools to make instruction more effective, efficient, and interesting to the learners.

To enrich instruction is to provide the learners with systematic and carefully developed instructional materials designed to meet and support learners with varying levels of ability and skills. A worktext, as a hybrid of a workbook and a textbook, offers a unique learning approach that combines theoretical content with practical exercises. Designed to promote active learning, it engages students in hands-on activities, encouraging them to apply mathematical principles in real-world contexts. By using worktexts, educators aim to create a dynamic learning environment that fosters critical thinking and deep understanding of the subject matter.

This study focuses on the development and acceptability of a worktext in Differential Calculus to improve the mathematics proficiency of students at University of Rizal System. The primary objective is to create a comprehensive, accessible, and engaging worktext that addresses the learning needs and preferences of the students. It is envisioned to cover fundamental topics in differential calculus based on CHED Memorandum Order (CMO) No. 12, series of 2008 such as limits, derivatives, and their applications. In addition to the development of the worktext, it also aims to evaluate degree to which the students find the worktext useful, user-friendly, and effective in facilitating their learning experience. By conducting acceptability assessments and gathering feedbacks, the researchers can make necessary improvements to enhance the worktext's overall class and quality.

Methods and Methodology

This study utilized the descriptive Developmental research. According to Richey, Rita C. (2004), developmental research has been defined as the systematic study of designing, developing, and evaluating instructional programs, processes, and products that must meet criteria of internal consistency and effectiveness. It is particularly important in the field of instructional technology which involve situations in which the product-development process is analyzed and described, and the final product is evaluated.

This method is suitable for this study as the researchers have developed a worktext in Differential Calculus in accordance with the course outline prescribed by the Commission on Higher Education.

The researchers employed a systematic approach utilizing the ADDIE framework described by Aldoobie (2015). ADDIE is an acronym for analysis, design, development, implementation, and evaluation. Each phase represents the fundamental concepts of the ID process and is related to and interact with each other ensuring that the design must be student-centered, goal-oriented with meaningful performance and outcomes that can be validly measured (Reiser & Dempsey, 2012)

In the analysis phase, the researchers examined and surveyed the existing knowledge, skills, experience, characteristics, and attitudes of 234 students taking Differential Calculus course - the target learners and determined instructional goals as well as the learning environment. As Beishuizen and Stoutjesdijk (1999) stated that the quality of learning material is enhanced if the students' learning styles are considered. To recognize the needs of students, result of diagnostic test was carefully

examined, review of related studies and literature followed, where developing a worktext in Differential Calculus was planned and conceptualized.

In the design phase, designer identifies the learning objectives to outline contents and instructional strategies. Features like styles, exercises, activities and references were mapped out. Contents of the worktext matched the outline prescribed by the Commission on Higher Education Memorandum Order (CMO) No. 12, series of 2008 (CHED, 2008). The contents are as follows:

1. Functions, Limits and Continuity
2. The Derivatives: Algebraic Functions
3. The Tangent line, Normal Line and Rate of Change
4. The Chain Rule and General Power Rule
5. Analysis of Functions
6. Applications of Derivatives: Optimization Problems
7. Derivatives of Trigonometric and Inverse Trigonometric Functions
8. Derivatives of Exponential and Logarithmic Functions
9. Derivatives of Hyperbolic and Inverse Hyperbolic Functions
10. Parametric Equations
11. Partial Differentiation

In the develop phase, careful analysis and study were undertaken where learning outcomes were stated before each topic. In such manner, learners would have a clear idea of what can be achieved at the end of each course. The Bloom's Taxonomy is helpful in writing the learning objectives and classifying them based on complexity and specificity using the cognitive, psychomotor, and affective learning domains (Adams, 2015). Based on the identified learning outcomes, teaching context, learning activities and assessment scheme was properly designed and discussions were made simple for students to appreciate and successfully understand the lesson. Problem based learning is applied, where lots of drills were emphasized. Hence, the designer would think of how the instruction can be effective in ways that able the learners to interact with the materials (Aldoobie, 2015). At this stage, the development of the worktext, cover design, layout, font selection, editing, validation, and revisions are carried out by determining the level of acceptability of mathematics experts in terms of content, relevance, style and presentation, usefulness, and clarity. Evaluation instrument together with the worktext was evaluated by distributing it to the experts. These experts are those professors in the university having thought the course for at least 5 years which also include some senior high school (SHS) teachers handling the course in the STEM strand.

For the implementation phase, the researchers revised, amended, and reconsidered all the comments and suggestions made by the experts after their thorough evaluation of the instrument's acceptability. The worktext was reproduced and handed over to the experimental group for their utilization to determine the impact on the quality of the learning process which includes, effectiveness, attractiveness, and efficiency. Respondents from the experimental group were allowed to use the worktext throughout the semester while the control group were treated by the usual lecture method without using the worktext.

For the evaluation phase, the quality and usefulness of the worktext was meticulously tested. The researchers made sure that the goals have been met and the worktext is efficient and effective. Aside

from administering a post test for the experimental and control group to find out the disparity in their performance, evaluation is carried out on each step to determine if flaw occurs in each procedure.

Results and Discussion

1. What instructional material may be developed to enhance the skills and competency of students based on the result of the diagnostic test in Differential Calculus?

The table shows the average performance of students in Differential Calculus for each topic with an overall average of 34.621.

Table 1. Result of Diagnostic Test in Differential Calculus

TOPICS	Average Score
1. Functions, Limits and Continuity	4.17
2. The Derivatives: Algebraic Functions	3.64
3. The Tangent line, Normal Line and Rate of Change	3.85
4. The Chain Rule and General Power Rule	3.04
5. Analysis of Functions	4.95
6. Applications of Derivatives: Optimization Problems	3.58
7. Derivatives of Trigonometric and Inverse Trigonometric Functions	3.61
8. Derivatives of Exponential and Logarithmic Functions	2.87
9. Derivatives of Hyperbolic and Inverse Hyperbolic Functions	2.96
10. Parametric Equations	1.83
11. Partial Differentiation	2.07
AVERAGE	32.651

The poor performance of the students is noted which emanates from a variety of challenges. These include lack of algebraic skills and conceptual knowledge. In a study of Domondon et. al. (2023) made emphasis that errors committed by students in Basic Calculus should be undertaken. He found out that students find Basic Calculus difficult. Moreover, some of the difficulties experienced by the students were on lack of knowledge of the concepts, poor application, complicated formulas and processes, and confusion in understanding the problem. The researchers noticed the students' lack of proficiency and difficulties in learning, mastering and deficiency of proper background in Calculus, from which development of worktext is conceptualized. As Dejarlo (2022) stated that teachers/professors be motivated to make their own worktext/module/ instructional materials to enhance the teaching-learning process of the course.

2. What is the level of acceptability of mathematics experts on the proposed work text in Differential Calculus in terms of:

- 2.1 content;
- 2.2 relevance;
- 2.3 style and presentation;
- 2.4 usefulness; and

2.5 clarity?

2.1 Content

The table shows that the respondents rated the items on content as **very acceptable**. Content is up-to-date with weighted mean of 4.73; content is accurate as shown by a weighted mean of 4.67; content is appropriate for college level with a weighted mean of 4.53; and content and skills are clearly stated and emphasize as supported by 4.60 weighted mean. Rated **acceptable** are the items: content which includes adequate development of concept and is appropriate for the student with a rating of 4.47 and content is relevant to students which received a rating of 4.20. The obtained overall mean value of 4.53 showed that the developed worktext has content very acceptable in the development of knowledge and skills in Differential Calculus.

Table 2. Level of Acceptability of Mathematics Experts on the Worktext in Terms of Content

Criteria	Weighted Mean	Interpretation
1. Content is up to date	4.73	VA
2. Content is accurate	4.67	VA
3. Content includes adequate development of concepts and is appropriate for the student.	4.47	VA
4. Content is appropriate for college level.	4.53	VA
5. Content is relevant to students.	4.20	A
6. Concept and skills to develop are clearly stated and emphasized	4.60	VA
Overall Mean	4.53	VA

Legend:

Scale Range Verbal Interpretation

5 – (4.50-5.00)	Very Acceptable	(VA)
4 – (3.50-4.49)	Acceptable	(A)
3 – (2.50-3.49)	Moderately Acceptable	(MA)
2 – (1.50-2.49)	Less Acceptable	(LA)
1 – (1.00-1.49)	Not Acceptable	(NA)

The data imply that the respondents have given very satisfactory ratings on the materials. These findings ascribed to the results of the study conducted by Geneta and Guinto “teacher performed different mathematical activities so as to guide the students in performing generalizations and at the same time developing their own skills.”

2.2 Relevance

The respondents agreed that the worktext has activities and learning areas relevant to the objectives and significant to the needs of the learner, skills are appropriate to the existing conditions and promote

relative evaluative manners, used for practical applications, and concepts being developed in each topic.

Table 3. Level of Acceptability of Mathematics Experts on the Worktext in of Relevance

Criteria	Weighted Mean	Interpretation
1. The activities are relevant to the objectives/skills.	4.67	VA
2. The material provides a variety of relevant evaluative measures.	4.67	VA
3. The materials are significant to the needs of the students.	4.20	A
4. The materials are relevant, interesting and self-motivating for the learner.	4.60	VA
5. The materials are to the concepts being developed in each topic.	4.60	VA
6. The materials can be used for practical applications	4.20	A
Overall Mean	4.49	A

Specifically, all items under relevance were rated *acceptable* as evidenced by an overall mean score ranging from 4.20 – 4.67 mean scores.

2.3 Style and Presentation

Table below reveals the assessment of the respondents as to style and presentation.

Table 3. Level of Acceptability of Mathematics Experts on the Worktext in Terms of Style and Presentation

Criteria	Weighted Mean	Interpretation
1. The language of the material is clear in terms of vocabulary and terms used.	4.33	A
2. The writing style of the material is conversational and friendly.	4.20	A
3. The material uses correct grammar	4.33	A
4. Skill lessons are presented in logical order.	4.20	A
5. There are enough activities at the end of each lesson.	4.20	A
6. The level of the language used is appropriate to the level of the learners.	4.53	VA
Overall Mean	4.30	A

The respondents agreed that the worktext is clear in terms of vocabulary, style of the material is friendly; correct grammar is used; skill lessons are presented in logical order; enough activities at the end of the lessons; and language used are appropriate to the level of the learners.

The math experts agreed that the modular instructional material in terms of style and presentation is *acceptable* as evidenced by the overall composite mean of **4.30**.

2.4 Usefulness

Based on the table below, the respondents agreed as to the usefulness of that the worktext in Differential Calculus as acceptable. They all agreed that the worktext (differentiation and its applications) prepares the students to think logically and critically, simple, and comprehensive, encourages the students to become actively involved in learning activities and seek to relate new learning from previous learning.

The math experts agreed that the worktext in terms of usefulness is **acceptable** as evidenced by the overall composite mean of **4.48**.

Table 4. Level of Acceptability of Mathematics Experts on the Worktext in Terms of Usefulness

Criteria	Weighted Mean	Interpretation
1. The materials prepare the students to think logically and critically.	4.67	VA
2. The concepts in the material are simple and comprehensible.	4.73	VA
3. As a whole the materials are teachable.	4.53	VA
4. The materials provide opportunity for the development/enhancement of mathematical skills.	4.53	VA
5. The learning contents provide adequate information on the topics presented.	4.33	A
6. They encourage the students to become actively involved in the learning activities.	4.20	A
7. They stimulate the learners to intellectual activities.	4.33	A
8. The activities seek to relate new learning from previous learning.	4.53	VA
Overall Mean	4.48	A

2.5 Clarity

It can be gleaned from the table that the respondents rated the worktext in Differential Calculus as acceptable with an overall composite mean of 4.27. This shows that the instructional material is clear and easy to understand. Concepts for each activity are arranged logically to ensure that there is no duplication of content, and clear, simple, and engaging.

Table 5. Level of Acceptability of Mathematics Experts on the Worktext in Terms of Clarity

Criteria	Weighted Mean	Interpretation
1. Information is clear, simple and engaging	4.20	A
2. Language used is clear and easy to understand	4.33	A
3. Students can assess their understanding at regular interval.	4.20	A

4. The concepts for each activity are arranged logically to ensure that there is no duplication of content	4.33	A
Overall Mean	4.27	A

As a summary, the acceptability of the developed worktext as assessed by the math experts is shown below

Table 6. Summary the Acceptability of Worktext in Differential Calculus

Criteria	Weighted Mean	Interpretation
1. Content	4.53	VA
2. Relevance	4.49	A
3. Style and Presentation	4.30	A
4. Usefulness	4.48	A
5. Clarity	4.27	A
Overall Mean	4.41	A

Legend:

Scale Range Verbal Interpretation

5 – (4.50-5.00)	Very Acceptable	(VA)
4 – (3.50-4.49)	Acceptable	(A)
3 – (2.50-3.49)	Moderately Acceptable	(MA)
2 – (1.50-2.49)	Less Acceptable	(LA)
1 – (1.00-1.49)	Not Acceptable	(NA)

It can be seen from the table that the developed worktext was *very acceptable* to the respondents as supported by the mean scores of 4.53 for content and *acceptable* to the respondents with a mean score of 4.49 for relevance, 4.30 for style and presentation, 4.48 for usefulness, and 4.27 for clarity. This was further supported by the overall mean score of 4.41.

This means that the topics, objective, content and activities of instructional materials are organized and sequenced logically; the style and presentation used is simple and easy to understand; the exercises; diagrams are adequate and relevant to the concepts and skills; and suit the needs of the students.

These foregoing results supported the findings of Cariño, Fajardo, Pineda, Marin, and Aguide that the use of instructional materials as a method of teaching keeps the learners busy, with their own work thus minimizing classroom management problems and also increase the span of students' interest and attention.

They also suggested that using the strategies of such instruction involving modular instructional materials prepares students for the mastery of the lessons, since the students can study at their own level and time.

3 Is there a significant difference in the performance between the experimental and control group in Differential Calculus after worktext was utilized?

The table provides an overview of the performance of the Control Group in the Differential Calculus course. In "Functions, Limits, and Continuity," the mean score is 6.15, which implies that, on average, students in the Control Group achieved a score of 6.15 out of the total possible score for this topic. The standard deviation measures the spread or variability of scores within the Control Group for each topic. A smaller standard deviation indicates that the scores are closer to the mean, suggesting more consistent performance among students. Conversely, a larger standard deviation implies greater variability in scores, indicating a wider range of performance.

Table 7. Performance of the Control Group in Differential Calculus

Topics	mean (x)	Standard deviation	Verbal interpretations
1. Functions, Limits and Continuity	6.15	1.2	Very Satisfactory
2. The Derivatives: Algebraic Functions	5.45	1.1	Satisfactory
3. The Tangent line, Normal Line and Rate of Change	5.78	1.04	Satisfactory
4. The Chain Rule and General Power Rule	5.95	1.12	Satisfactory
5. Analysis of Functions	5.8	0.995	Satisfactory
6. Applications of Derivatives: Optimization Problems	5.71	0.92	Satisfactory
7. Derivatives of Trigonometric and Inverse Trigonometric Functions	6.12	1.45	Very Satisfactory
8. Derivatives of Exponential and Logarithmic Functions	5.45	1.27	Satisfactory
9. Derivatives of Hyperbolic and Inverse Hyperbolic Functions	5.15	1.26	Satisfactory
10. Parametric Equations	5.12	1.28	Satisfactory
11. Partial Differentiation	5.97	1.27	Satisfactory
Average	62.65		Satisfactory

The verbal interpretations in the last column provide a qualitative assessment of the students' performance for each topic. The terms used are "Very Satisfactory" and "Satisfactory." "Very Satisfactory" suggests that the students performed exceptionally well in the topic, while "Satisfactory" indicates a satisfactory performance, though not outstanding.

Finally, the table presents an overall average for all the topics, which is calculated to be **62.65**. The average score is also labeled as "Satisfactory," which indicates that, on average, the Control Group achieved satisfactory results across all the topics covered in the Differential Calculus course.

Table 8. Performance of the Experimental Group in Differential Calculus

Topics	mean (x)	Standard deviation	Verbal interpretations
1. Functions, Limits and Continuity	7.23	1.024	Very Satisfactory
2. The Derivatives: Algebraic Functions	7.15	0.994	Very Satisfactory
3. The Tangent line, Normal Line and Rate of Change	6.85	1.14	Very Satisfactory
4. The Chain Rule and General Power Rule	7.01	0.927	Very Satisfactory
5. Analysis of Functions	6.5	0.854	Very Satisfactory
6. Applications of Derivatives: Optimization Problems	6.25	0.88	Very Satisfactory
7. Derivatives of Trigonometric and Inverse Trigonometric Functions	7.5	0.947	Very Satisfactory
8. Derivatives of Exponential and Logarithmic Functions	7.45	95	Very Satisfactory
9. Derivatives of Hyperbolic and Inverse Hyperbolic Functions	6.05	1.04	Satisfactory
10. Parametric Equations	5.95	1.17	Satisfactory
11. Partial Differentiation	7.15	0.954	Very Satisfactory
Average	75.09		Very Satisfactory

The above table presents the performance of the Experimental Group, who utilized the developed worktext in the Differential Calculus. It is evident that the Experimental Group, which had access to the developed worktext, achieved notably higher mean scores compared to the Control Group in almost all topics. The mean scores for each topic are consistently above 6, indicating a relatively strong performance across the board. Specifically, the mean scores range from 5.95 to 7.5, with most topics scoring above 7, signifying a high level of competence.

The standard deviations, which represent the spread or variability of scores within the Experimental Group, are generally smaller for most topics. This suggests that students in the Experimental Group exhibited more consistent performance compared to the Control Group. The verbal interpretations accompanying the mean scores reinforce the high level of achievement observed in the Experimental Group. Terms like "Very Satisfactory" are used repeatedly, indicating that the students' performance in most topics was exceptional. In particular, topics like "The Derivatives: Algebraic Functions," "The Chain Rule and General Power Rule," and "Derivatives of Exponential and Logarithmic Functions" received consistently high praise, with a mean score of 7.15 or above and standard deviations below 1.

However, it is worth noting that two topics, "Derivatives of Hyperbolic and Inverse Hyperbolic Functions" and "Parametric Equations," were assessed with mean scores below 6. These topics received a "Satisfactory" verbal interpretation, suggesting that while the students' performance was acceptable, there is room for improvement. Overall, the Experimental Group exhibited a significantly higher average mean score of **75.09** compared to the Control Group's average of 62.65. This impressive

average indicates that the use of the specialized worktext had a positive impact on the students' learning and understanding of Differential Calculus. It is apparent that the worktext effectively contributed to the Experimental Group's overall very satisfactory performance, validating its development and successful implementation in the course.

The table provides the statistical analysis results of the performance of the Experimental Group and the Control Group in utilizing the worktext in the Differential Calculus course.

Table 9. Significant difference in the Performance of the Experimental Group and Control Group in utilizing Work text in Differential Calculus

Topics	t-values	df	Sig (< .05)	H ₀ (Null Hypothesis) at .05	VI
1. Functions, Limits and Continuity	6.17	9	0.000	Rejected	Significant
2. The Derivatives: Algebraic Functions	5.45	9	0.001	Rejected	Significant
3. The Tangent line, Normal Line and Rate of Change	8.40	9	0.000	Rejected	Significant
4. The Chain Rule and General Power Rule	7.14	9	0.000	Rejected	Significant
5. Analysis of Functions	6.85	9	0.000	Rejected	Significant
6. Applications of Derivatives: Optimization Problems	7.12	9	0.000	Rejected	Significant
7. Derivatives of Trigonometric and Inverse Trigonometric Functions	8.29	9	0.001	Rejected	Significant
8. Derivatives of Exponential and Logarithmic Functions	7.23	9	0.000	Rejected	Significant
9. Derivatives of Hyperbolic and Inverse Hyperbolic Functions	7.56	9	0.000	Rejected	Significant
10. Parametric Equations	7.28	9	0.000	Rejected	Significant
11. Partial Differentiation	8.36	9	0.000	Rejected	Significant

The *t-value* is a measure of the difference between the means of the Experimental and Control Groups for each specific topic. It indicates the extent to which the Experimental Group's performance differs from that of the Control Group. In this table, all the t-values are positive, indicating that the Experimental Group consistently outperformed the Control Group in every topic.

The significance level (Sig) shows the probability of obtaining the observed difference between the means by chance alone. A Sig value of less than 0.05 ($p < 0.05$) indicates that the results are statistically significant, suggesting that the observed differences are unlikely to have occurred by random chance. The null hypothesis (H₀) states that there is no significant difference between the Experimental and Control Groups in utilizing the worktext in Differential Calculus. However, based on the results in the table, the null hypothesis is rejected for all topics, as the Sig values are less than 0.05. This rejection indicates that there is a significant difference between the control group, and the Experimental Group's utilization of the worktext has led to a significantly better performance compared to the Control Group.

The table's statistical analysis reinforces that the worktext played a crucial role in enhancing the students' learning and understanding of Differential Calculus. The significant differences observed in the Experimental Group's performance across all topics indicate the effectiveness of the worktext as an instructional tool in improving students' academic outcomes in this course.

Conclusion

1. The mathematics experts found the developed worktext highly acceptable, as evidenced by the mean scores of 4.53 for content and 4.49 for relevance. Additionally, the material received favorable ratings for style and presentation (mean score of 4.30), usefulness (mean score of 4.48), and clarity (mean score of 4.27). The overall mean score of 4.41 further supports the material's strong acceptability. These scores indicate that the instructional material's topics, objectives, content, and activities are logically organized and sequenced. The style and presentation are simple and easy to comprehend, while the exercises, and diagrams effectively relate to the concepts and skills, meeting the students' needs.
2. The Control Group achieved satisfactory results across all the topics covered in the Differential Calculus course, but the used of the work text had a more beneficial effect on the students' learning and grasp of Differential Calculus. The worktext played a significant role in enhancing the Experimental Group's performance, leading to an overall very satisfactory outcome. This outcome validates the successful development and integration of the worktext into the course.
3. The null hypotheses were rejected for all topics, as the Sig values are less than 0.05. This rejection indicates that there is a significant difference between the groups, and the Experimental Group's utilization of the worktext has led to a significantly better performance compared to the Control Group.

Acknowledgement

The researchers would like to thank the University of Rizal System, with the President Dr. Nancy T. Pascual, Dr. Florante J. Mercado, Campus Director of URS - Rodriguez, colleagues, to students, their families who provided the support and motivation, and most of all to Almighty God for the continuous guidance and strength to complete this study.

Funding Statement: The authors did not receive any funding for the development of this research.

Data Availability: The data that support the findings of this study are available upon request from the corresponding author, [Jose D. Elveña Jr.].

Conflict of Interest: The authors declare that there is no conflict of interest.

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