

Comparative Analysis of Mobile Applications for its Integration in College Mathematics Subjects

Engr. John Vincent L. Santos

Holy Cross College, Sta. Rosa, N.E., Inc.

[Email: j.vince103@gmail.com](mailto:j.vince103@gmail.com)

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Abstract: The purpose of this study is to investigate potential mobile applications that can be utilized to help college students learn mathematical ideas and principles. The considered mobile applications include those that have a solving feature and are named as follows: MalMath, MyScript Calculator, Photomath, iMathematics, Microsoft Math Solver, Mathway, Socratic, WolframAlpha, and Cymath. These mobile applications were evaluated subjectively and statistically to identify which is/are the most suitable for utilization in a flexible learning environment, while also considering their benefits and drawbacks in the teaching-learning process. This study took into account various app features such as subject coverage, interface, accessibility, and so on, which will serve as the common criteria for evaluation. Each criterion was rated and ranked accordingly. The Related-Samples Friedman's Two-Way Analysis of Variance by Ranks, a nonparametric statistical test, was used to evaluate the rank-ordered data set of numerous mobile applications premised on a common criterion. In the case that there is a significant tendency for a math solving application/s to rank systematically higher or lower based on the results of Statistical test employed, Pairwise Comparisons was conducted. Following that, a comparative analysis was performed to get findings and recommendations for the prospective integration of mobile apps. Furthermore, this research will help with information distribution and creating awareness regarding the utilization of mobile applications in the teaching-learning process. The advantages and disadvantages of adopting mobile applications will help educators successfully facilitate the teaching-learning process. While the students will be encouraged to use the mobile application/s to enhance their mathematics literacy and problem-solving skills.

Keyword: Higher Education Mathematics, Quantitative Analysis, Qualitative Analysis, Math App, Problem Solving, Educational Technology

Introduction

The progress of technology is being seen in our daily lives at a tremendous pace. We utilize gadgets such as cellphones, tablets, and laptop computers, as well as apps that are integrated with the usage of such technology¹. Most individuals use technology to make difficult tasks simpler, such as communication, transportation, and information distribution. The limits of technical capabilities are largely uncontrollable, and their use may be both advantageous and harmful. When technology is integrated into education and how it may be utilized to promote learning, both challenges and opportunities occur².

¹ Anders Andrae and Tomas Edler, "On Global Electricity Usage of Communication Technology: Trends to 2030," *Challenges* (2015); Edna Maeyen Solomon and Aaron van Klyton, "The Impact of Digital Technology Usage on Economic Growth in Africa," *Utilities Policy* (2020).

² Evgeny Aleksandrov and Anastasia Levitskaya, "Technology of Integrated Media Education,"

Mobile smartphones are the handiest and easily available tool for most instructors and students. Despite its tiny size, it has the potential to become highly powerful teaching and learning tool. Applications with various functionalities may be loaded on mobile devices.

Nowadays, there is a multitude of mobile applications accessible on the internet that students may use to aid them with their academics, especially in mathematics. Math is a famously tough topic, so if a student can answer a problem without struggle, it might motivate them to do their best throughout their studies. These applications can shorten the lengthy process of problem-solving, graphing, and trial and error by simply pressing buttons and entering data into mobile devices³.

Fortunately, there are a great number of math programs available that may explain and may guide the learner through various strategies for grasping the complexities of algebra, geometry, calculus, trigonometry, and advanced mathematics courses. The instructors and the students are advised to utilize digital technology. New methods of learning are being introduced such as online classes to reach each other distantly and proceed with the academic learning to avoid its disruption.

In this study, nine (9) math applications are chosen to be examined in terms of their potential influence on the study of college students pursuing mathematical topics. These applications are specifically and briefly explained as follows:

1. MalMath - This application takes mathematical problems and solves them with detailed explanations, guiding students from problem to solution to insight in easy, well-explained steps. One of the finest aspects of this free software is its excellent offline capabilities, which allow students to continue learning even if they are not connected to the internet.
2. MyScript Calculator – This math app can recognize your handwriting. This means that you will get answers to your math problem by merely writing the question on the screen. This app supports basic arithmetic with square roots and cube roots but not trigonometry, percentages, and logarithms.
3. Photomath - This Android application is used for explaining difficult math sets, ranging from elementary math to calculus and trigonometry. It takes a photo of a math issue with a smartphone camera, analyzes the data, and provides a thorough step-by-step answer and explanation. It is a free program with the great feature of functioning offline when utilizing the minimal core.
4. iMathematics – This application lets the user type in equations and solves them. Aside from this, the app also includes various learning modules. The only downside is that the user has to enter the equations manually – the user can't just take a picture of the equations.
5. Microsoft Math Solver - This math solver app makes use of an advanced AI to solve a variety of different math problems with ease. This math solution app is quite simple to use and offers three ways in which the user can input a new math problem. The user can either enter an equation using the built-in calculator-like interface, click a photo of the problem, or write the math problem by hand.
6. Mathway – This is a math problem solving app and algebra calculator that offers instant

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³ Anshita Dhoot, "A Survey of Internet of Things," *SYNCHROINFO JOURNAL* (2020); Neda Shahriari, Jane Grant-Kels, and Michael J. Murphy, "Dermatopathology Education in the Era of Modern Technology," *Journal of Cutaneous Pathology*, 2017.

- answers to the users most complex math equations. This math problem solver practically solves anything from basic math problems, geometry, algebra to more complex calculus equations and trigonometry.
7. Socratic – The app lets the user take a picture of a problem and it'll not only give you an answer, but the steps necessary to arrive at that answer — and even detailed explanations of the steps and concepts if needed.
 8. WolframAlpha – This application aims to ‘make all systematic knowledge immediately computable and accessible to everyone capable’. This math solution app shouldn't be mistaken for a search engine even though it looks like one. It is an informational tool that delivers specific answers calculated from the data gathered from all the information related to the entered questions.
 9. Cymath – This math solver app provides help with a variety of problems including arithmetic, algebra, trigonometry, calculus, statistics, and other topics using an advanced AI powered math solver. It is a math app that gives math answers based on a wide variety of topics.

The fundamental goal of good teaching is to effect the desired change in learning behavior. It is caused by the teacher's use of teaching methods to achieve the lesson's objectives. This makes teaching more difficult, but also tougher because it necessitates diverse approaches and strategies for varied student skills and behavior.

Today's educational systems strive to incorporate technology into education through computerized programs, mobile software, as well as raise instructors' knowledge of the growth of computerized and mobile apps in the classroom.

In recent years, academics have created online and mobile applications to aid in the teaching of Algebra, Geometry, Mathematical Analysis, Statistics, and other subjects. Mobile math applications allow users to investigate functions, provide graphical capabilities, and provide a variety of calculators. There are measuring apps as well as instructional applications for honing numerical and mathematical abilities.

Over the last decade, technologies that facilitate mathematics on the web have also grown in popularity. Online and mobile teaching tools for mathematics can help students solve problems, understand mathematical concepts better, give dynamic representations of ideas, and develop general metacognitive abilities. On the one hand, regular use of mobile technology in the course of mathematics would help students enhance their skills, while on the other hand, it would promote the development of mobile learning apps.

The following questions are explicitly addressed by this research:

- a. What are the potential benefits and drawbacks of employing such mobile applications in the teaching-learning process?
- b. Which mobile applications are most suited to assisting teachers in enhancing and enriching their assessments in order to successfully aid the teaching-learning process in mathematics?
- c. Which mobile applications are most suited to assist learners in improving their mathematical literacy and problem-solving abilities?

METHODS

The conceptual framework of this study is divided into 5 phases. The phases are listed below as follows:

1. Listing of Math Solving Apps

The first step is to make a list of all conceivable mathematical applications that can be integrated with the learners' studies. The researcher chose nine (9) math applications after studying numerous websites on the internet that showcase the top math apps. Initial factors were the application's availability on mobile platforms, the ability to be downloaded from the Google Play store, availability on the user's location (in this case, Philippines), and the presence of a solving feature.

2. Identification and Evaluation of Criteria

The second step is to create a list of all the criteria that will be used to compare each mobile application. The criteria focus on capabilities rather than aesthetics. The solution features, input capability feature, learning guide feature, convenience feature, accessibility feature, and supplementary contents features are all part of the evaluation criteria.

Each criteria have 5 levels of rating. For example in the solving feature, There are 4 problems for each criterion with an increasing difficulty and complexity. Each problem solved corresponds to a 1 point in the criteria. If all problems are solved, 4 point rating is given. If no problem is solved, no point is given.

When all of the mobile apps are evaluated, they will be ranked accordingly. This gives rise into a rank-ordered data set that will require a non-parametric statistical treatment.

The most common and fundamental concepts of each subject are covered in the solution features. The same problems/questions will be solved by each mathematical application.

Solving Features (SF):

- 1) Integers (Arithmetic)
- 2) Fractions(Arithmetic)
- 3) Decimal Numbers (Arithmetic)
- 4) Percentage (Arithmetic)
- 5) Exponents (Arithmetic)
- 6) Radicals (Arithmetic)
- 7) Logarithms (Arithmetic)
- 8) Simplifying Simple Algebraic Expressions (Algebra)
- 9) Simplifying Algebraic Fractions (Algebra)
- 10) Simplifying Exponential Expressions (Algebra)
- 11) Simplifying Radical Expressions (Algebra)
- 12) Simplifying Logarithmic Expressions (Algebra)
- 13) Linear Equations (Algebra)
- 14) Higher Ordered Equations (Algebra)
- 15) Linear Inequalities (Algebra)
- 16) Higher Ordered Inequalities (Algebra)
- 17) Equations with Absolute Value (Algebra)
- 18) Inequalities with Absolute Value (Algebra)
- 19) Word Problems (Algebra)
- 20) Matrices (Algebra)
- 21) Complex Numbers (Algebra)
- 22) Trigonometric Identities (Trigonometry)
- 23) Inverse Trigonometric Identities (Trigonometry)
- 24) Limits (Calculus)

- 25) Algebraic Differentiation (Calculus)
- 26) Trigonometric Differentiation (Calculus)
- 27) Inverse Trigonometric Differentiation (Calculus)
- 28) Logarithmic Differentiation (Calculus)
- 29) Exponential Differentiation (Calculus)
- 30) Algebraic Integration (Calculus)
- 31) Trigonometric Integration (Calculus)
- 32) Inverse Trigonometric Integration (Calculus)
- 33) Logarithmic Integration (Calculus)
- 34) Exponential Integration (Calculus)
- 35) Summation (Statistics)
- 36) Permutations (Statistics)
- 37) Combinations (Statistics)
- 38) Factorials (Statistics)

This criteria part pertains to the application's capacity to input the required problems to be solved.

Input Capability Feature (ICF):

- 39) Picture (Input of Problem)
- 40) Scanning (Input of Problem)
- 41) Keying (Input of Problem)
- 42) Handwriting (Input of Problem)
- 43) Voice (Input of Problem)

The learning guide feature refers to how the math app displays and guides learners through the step-by-step method for answering a problem.

Learning Guide Features (LGF):

- 44) Searching Online
- 45) Step by Step Guide
- 46) How-to Animations/Videos

The convenience feature refers to the math app's efficiency in storing, preserving, and distributing the knowledge from the solved problem.

Convenience Features (CF):

- 47) Multiple Problem Solving
- 48) Saving Solution/Graph
- 49) Sharing Solution/Graph
- 50) Addition of Personal Note

The accessibility feature refers to how the user may access the program. The app can be paid or free, and it can be used online or offline.

Accessibility features (AF):

- 51) Free to Use
- 52) Offline Content

Some math applications aren't only for problem solving; some offer additional mathematical material that might help students learn more about ideas, principles, and other math disciplines.

Supplementary Content Features (SCF):

- 53) Mathematical Definitions

- 54) Mathematical Theorems
- 55) Mathematical Illustrations
- 56) Mathematical Formulas
- 57) Mathematical Tables
- 58) Conversion of Units
- 59) Graph Plotting and Analysis
- 60) Scientific Calculator

3. Statistical Tests – Friedman Test and Post Hoc Tests

Statistical tests are necessary to make inference for the population from the sample taken. In this study, the sample are the listed evaluative criteria since it is impossible to compare all the existing features (population) of mobile application. For each criterion, the math apps will be ranked. The common evaluation criteria served as the independent sample, while the nine (9) math apps served as the dependent samples in this study.

A rank-ordered data set requires a non-parametric statistical treatment. With the samples identified as multiple independent, a Friedman test is conducted. In the case that the math applications are significantly different from one another, post hoc test will be followed up.

4. Comparative Analysis

The comparative analysis is divided into two stages, namely: Quantitative comparison using statistical test and Qualitative comparison using quality observations by the researcher.

The Quantitative comparison determines the significant difference or similarity of the math applications based on the criteria evaluated.

The Qualitative comparison determines the features and capabilities of math applications not included in the criteria through the first-hand experience and observations of the researcher.

5. Integration of Math Solving Apps

The comparative analysis was carried out in order to get findings and recommendations for the future integration of mobile apps. These recommendations cover the benefits and drawbacks of using mobile applications to assist instructors in successfully facilitating the teaching-learning process and encouraging students to utilize mobile applications to improve their mathematical literacy and problem-solving abilities.

RESULT AND DISCUSSION

In this section, we report the results of the techno-ethical audit of Google Meet and Classroom. Findings are reported as analysis of the dimensions of the audit - that is, how Google Meet and Classroom afforded (or not) educational justice according to legal, economic, democratic, technological, and pedagogical lines. For each of the above dimensions, we contextualize how the design of educational technologies relates to the experience of online learning and carries broader consequences for society as a whole.

1. Solving Features

The solving feature criteria encompasses the subjects arithmetic, algebra, trigonometry, calculus and statistics. Based on the Table 1, the result of the statistical tests applied states that there is a significant difference between the nine (9) tested mathematics applications in terms of solving features. Therefore, a post-hoc test, specifically the pairwise comparisons, is applied in this criteria this criterion to determine which math apps are ranked systematically lower or higher than other.

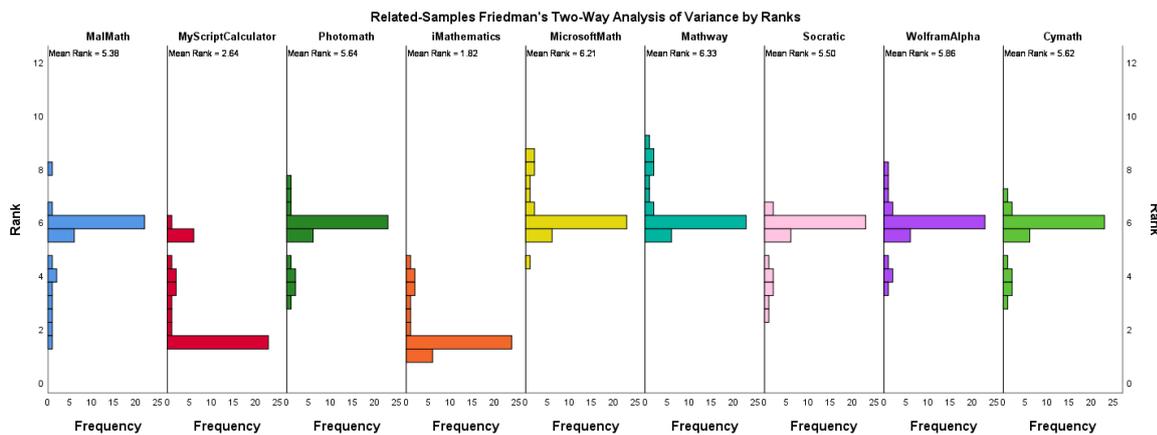
Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 1. Hypothesis Test Summary for Solving Features

Graph 1 shows that the math app with highest mean rank in terms of solving feature is the Mathway (Mean rank = 6.33). Mathway is the only math app that solved all the questions/problems listed by the researcher in the criteria. However, Pairwise comparisons in Table 2 shows that there is no significant difference between Mathway and the math apps: Microsoft Math Solver (Mean rank = 6.21), Wolfram Alpha (Mean rank = 5.86), Photomath (Mean rank = 5.64), Cymath (Mean rank = 5.62), Socratic (Mean rank = 5.50), and Malmath (Mean rank = 5.38). The remaining math apps Myscript Calculator (Mean rank = 2.64) and iMathematics (Mean rank = 1.82) shows no significant difference and are listed with the lowest mean ranks in terms of Solving Features.



Graph 1. Mean Ranks for Solving Features

2. Input Capability Features

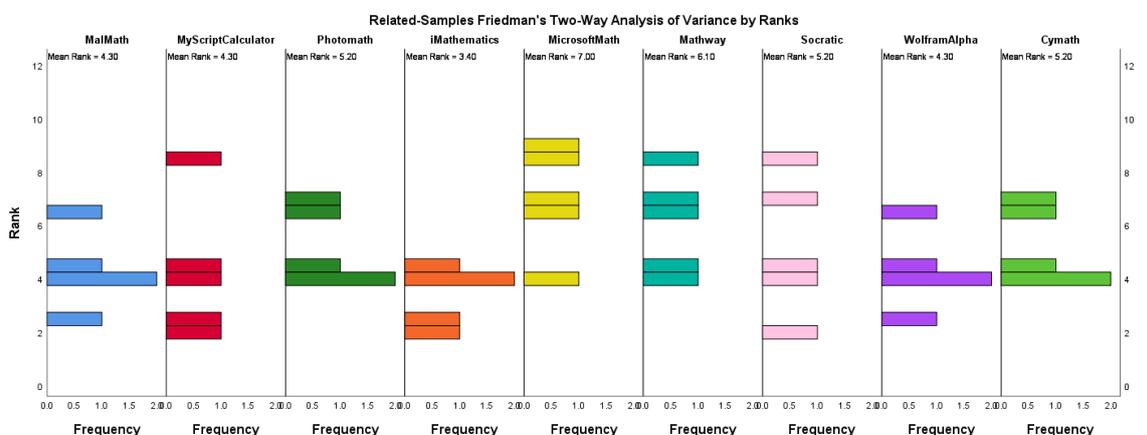
Based on the Table 2, the result of the statistical tests applied states that there is no significant difference between the nine (9) tested mathematics applications in terms of Input Capability Features. Therefore, the researcher shall retain the null hypothesis and there is no need to conduct posthoc tests.

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.188	Retain the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.188	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 2. Hypothesis Test Summary for Input Capability Features.

Looking at Graph 2, the math app that got the highest mean rank is Microsoft Math Solver (Mean rank = 7.00). Microsoft Math is the only application with 4 input capabilities, namely: Picture, Scanning, Keying and Handwriting input. However, statistically speaking, Microsoft math is not different from the other eight (8) math apps in terms of Input Capability Features.



Graph 2. Mean Ranks for Input Capability Features

3. Learning Guide Features

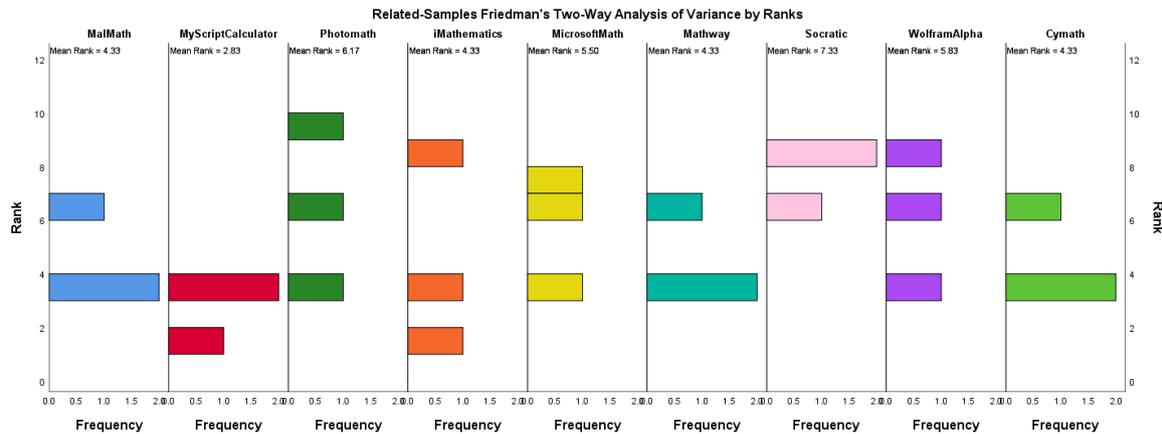
Based on the Table 3, the result of the statistical tests applied states that there is no significant difference between the nine (9) tested mathematics applications in terms of Learning Guide Features. Therefore, the researcher shall retain the null hypothesis and there is no need to conduct posthoc tests.

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.347	Retain the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.347	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 3. Hypothesis Test Summary for Learning Guide Features

Looking at Graph 3, the math app that got the highest mean rank is Socratic (Mean rank = 7.33). Socratic is the only application with which is directly connected with other math app so the user may have a variety of solutions. The app includes Mathway, Cymath, MathPapa and Wolfram Alpha. Additionally, Socratic is directly connected with the online resources. However, statistically speaking, Socratic is not different from the other eight (8) math apps in terms of Learning Guide Features.



Graph 3. Mean Ranks for Learning Guide Features

4. Convenience Features

Based on the Table 4, the result of the statistical tests applied states that there is a significant difference between the nine (9) tested mathematics applications. Therefore, a posthoc test, specifically the pairwise comparisons, is applied in this criteria this criterion to determine which math apps are ranked systematically lower or higher than other.

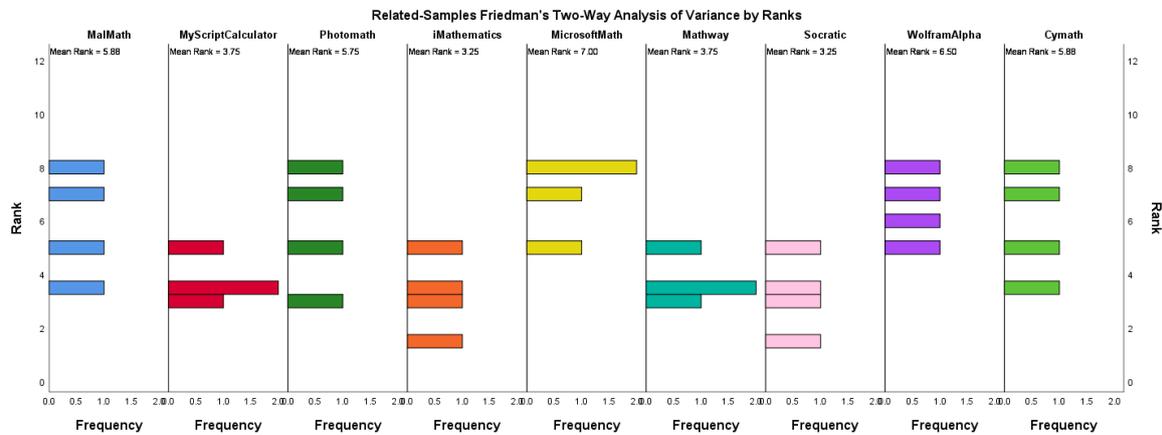
Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.037	Reject the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.037	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 4. Hypothesis Test Summary for Convenience Features

Graph 4 shows that the math app with highest mean rank in terms of convenience features is the Microsoft Math Solver (Mean rank = 7.00). Microsoft Math can save and share questions and problems. However, Pairwise comparisons in Table 6 shows that there is no significant difference between all other math apps. Which shows contradictory results from the hypothesis result summary. A common reason behind these may be due to fact that the criteria in Convenience Feature is only small in number. And when there is a small sample size, Pairwise comparison test may less likely to detect significant differences. In this case, we may look at the

weak evidences (significant values between 0.05 and 0.1) to reject the null hypothesis to create separation between the math apps that justify that there is a significant in terms of convenience features. Microsoft Math Solver is statistically the same with Wolfram Alpha (Mean rank = 6.50), Malmath (Mean rank = 5.88), Cymath (Mean rank = 5.88), Photomath (Mean rank = 5.75). The math apps in lower ranking in terms of convenience are Myscript Calculator (Mean rank = 3.75), Mathway (Mean rank = 3.75), iMathematics (Mean rank = 3.25), and Socratic (Mean rank = 3.25).



Graph 4. Mean Ranks for Convenience Features

5. Accessibility Features

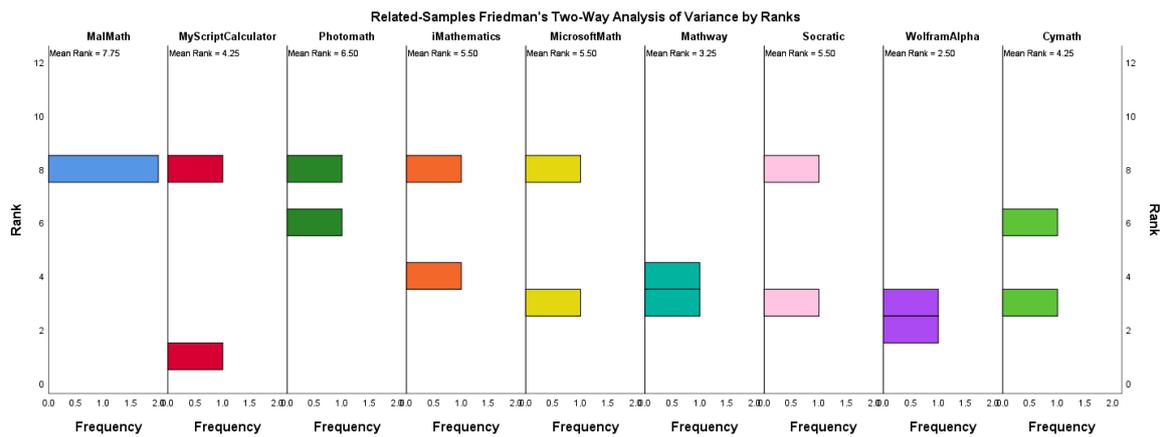
Based on the Table 5, the result of the statistical tests applied states that there is no significant difference between the nine (9) tested mathematics applications in terms of accessibility features. Therefore, the researcher shall retain the null hypothesis and there is no need to conduct posthoc tests.

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.582	Retain the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.582	Retain the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 5. Hypothesis Test Summary for Accessibility Features

Looking at Graph 5, the math app that got the highest mean rank is MalMath (Mean rank = 7.75). MalMath is the only math application that where all of the contents are free to use and can be used offline. However, statistically speaking, MalMath is not different from the other eight (8) math apps in terms of Input Capability Features



Graph 5. Mean Ranks for Accessibility Features

6. Supplementary Content Features

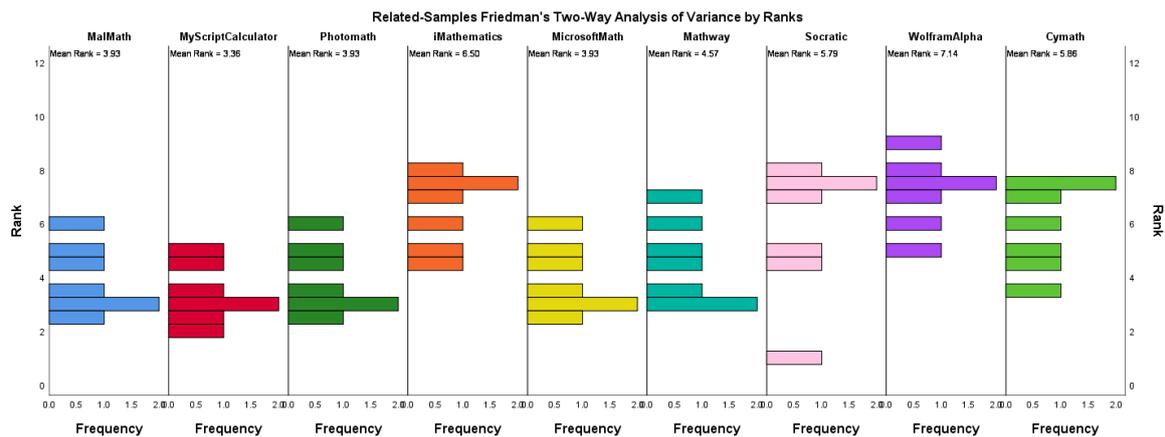
Based from the Table 6, the result of the statistical tests applied states that there is a significant difference between the nine (9) tested mathematics applications in terms of supplementary content features. Therefore, a posthoc test, specifically the pairwise comparisons, is applied in this criteria to determine which math apps are ranked systematically lower or higher than other.

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.001	Reject the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.001	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 6. Hypothesis Test Summary for Supplementary Content Features

Graph 6 shows that the math app with highest mean rank in terms of supplementary content features is the WolframAlpha (Mean rank = 7.14). WolframAlpha contains almost all listed supplementary contents in the criteria except the conversion of units feature. Pairwise comparisons in Table 9 shows that there is no significant difference between WolframAlpha and the math apps: iMathematics (Mean rank = 6.50), Socratic (Mean rank = 5.79), Cymath (Mean rank = 5.86) and Mathway (Mean rank = 4.57). The remaining math apps MalMath (Mean rank = 3.93), PhotoMath (Mean rank = 3.93), Microsoft Math Solver (Mean rank = 3.93), and MyScript Calculator (Mean rank = 3.36). shows no significant difference and are listed with the lowest mean ranks in terms of supplementary content features.



Graph 6. Mean Ranks for Supplementary Content Features

7. Overall Features

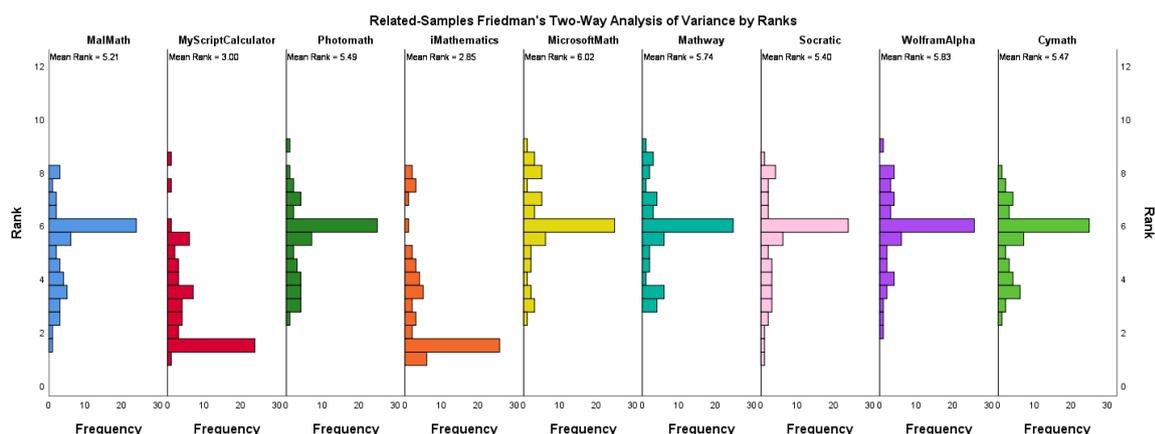
Based on the Table 7, the result of the statistical tests applied states that there is a significant difference between the nine (9) tested mathematics applications in terms of its overall features. Therefore, a posthoc test, specifically the pairwise comparisons, is applied in this criteria this criterion to determine which math apps are ranked systematically lower or higher than other.

Hypothesis Test Summary				
	Null Hypothesis	Test	Sig.	Decision
1	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Friedman's Two-Way Analysis of Variance by Ranks	.000	Reject the null hypothesis.
2	The distributions of MalMath, MyScriptCalculator, Photomath, iMathematics, MicrosoftMath, Mathway, Socratic, WolframAlpha and Cymath are the same.	Related-Samples Kendall's Coefficient of Concordance	.000	Reject the null hypothesis.

Asymptotic significances are displayed. The significance level is .050.

Table 7. Hypothesis Test Summary for Overall Features

Graph 7 shows that the math app with highest mean rank in terms of the overall features is the Microsoft Math Solver (Mean rank = 6.02). Microsoft Math has 4 out of 5 possible input of problem options, shows detailed Solutions and when solving a problem, it shows the graph, similar problems, video tutorials, related concepts, worksheets from web, and similar problems from web. Additionally, it can share solutions on social media and other platforms. Pairwise comparisons in Table 11 shows that there is no significant difference between Microsoft Math Solver and the math apps: WolframAlpha (Mean rank = 5.83), Mathway (Mean rank = 5.74), PhotoMath (Mean rank = 5.49), Cymath (Mean rank = 5.47), Socratic (Mean rank = 5.40), and Malmath (Mean rank = 5.21). The remaining math apps Myscript Calculator (Mean rank = 3.00), and iMathematics (Mean rank = 2.85). shows no significant difference and are listed with the lowest mean ranks in terms of overall features.



Graph 7. Mean Ranks for Overall Features

The researcher listed the observations below during the evaluation phase of the study.

Qualitative Observations During the Evaluation of Criteria

Mobile Application	Solving Features	Input Capability Features	Learning Guide Features	Convenience Features	Accessibility Features	Supplementary Content Features
1. MalMath 	<ul style="list-style-type: none"> - Offers multiple answer (solutions) to a problem - Can solve problems including arithmetic, algebra, trigonometry, and calculus. - Cannot solve word problems, matrices, complex number, statistics and probability. 	<ul style="list-style-type: none"> - The user can input problems through keying - Difficulty in the input of more complex equations such as integration - Some input features are hidden. The user have to long press the button to show other symbols. 	<ul style="list-style-type: none"> - Shows detailed steps and solutions and what methods are taken to solve the problem 	<ul style="list-style-type: none"> - Saves all solved problems - Can add favorite problems for savings 	<ul style="list-style-type: none"> - Free to Install - Photo input is a paid feature - Can be used offline 	<ul style="list-style-type: none"> - There is a problem generator for algebra, trigonometry, limit, differentiation and integral - There is a graph feature with limited capabilities - Equipped with Scientific Calculator
2. MyScript Calculator 	<ul style="list-style-type: none"> - Cannot recognize various symbols such as variables - limited to arithmetic solving 	<ul style="list-style-type: none"> - The user can input problems through handwriting - Can easily write the equations or problem on the screen 	<ul style="list-style-type: none"> - Does not show any steps in the arithmetic computation 	<ul style="list-style-type: none"> - Saves recent problems only 	<ul style="list-style-type: none"> - Paid application - Can be used offline 	<ul style="list-style-type: none"> - No supplementary contents

<p>3. Photomath</p> 	<ul style="list-style-type: none"> - Gives detailed solutions - Can generally solve almost every problem in the criteria expect for statistics and limits. 	<ul style="list-style-type: none"> - Solves with a free photo input feature 	<ul style="list-style-type: none"> - Shows detailed steps and solutions and what methods are taken to solve the problem 	<ul style="list-style-type: none"> - Saves all solved problems - It can share solutions on social media and other platforms 	<ul style="list-style-type: none"> - Free to Install - Additional features including animated tutorials requires payment - Requires internet connection 	<ul style="list-style-type: none"> - No supplementary contents
<p>4. iMathematics</p> 	<ul style="list-style-type: none"> - limited to solving linear and quadratic equations 	<ul style="list-style-type: none"> - The user can input problems through keying 	<ul style="list-style-type: none"> - Does not show any steps in the linear and quadratic equations computation 	<ul style="list-style-type: none"> - The user can search mathematical concepts and principles 	<ul style="list-style-type: none"> - Free to Install - Most of the additional contents are for pro version, however pro version seems unavailable - Some features Requires internet connection. 	<ul style="list-style-type: none"> - Equipped with supplementary contents for definitions, properties, theorems, principles, etc
<p>5. Microsoft Math Solver</p> 	<ul style="list-style-type: none"> - Can solve arithmetic, algebra, trigonometry, calculus and statistics. Every problem in the criteria except combinations. 	<ul style="list-style-type: none"> - The user can input the problem through picture, scanning, keying and handwriting. The only app with 4 different input features among the math apps in this study. 	<ul style="list-style-type: none"> - Shows detailed steps and solutions and what methods are taken to solve the problem - When solving a problem, it shows also the graph, similar problems, video tutorials, related concepts, worksheets from web, and similar 	<ul style="list-style-type: none"> - Saves all solved problems - It can share solutions on social media and other platforms - It can bookmark selected problems to easily find it 	<ul style="list-style-type: none"> - Free to Install - Requires internet connection 	<ul style="list-style-type: none"> - With Scientific Calculator - Contains Daily Practice quiz feature with summary of average score

			problems from web			
6. Mathway 	<ul style="list-style-type: none"> - Can solve arithmetic, algebra, trigonometry, calculus and statistics.. This app solved all problems in the criteria set by the researcher - The app helps the user decide on how will the problem be solved 	<ul style="list-style-type: none"> - The user can input problem through photo, keying or voice. - The app offers suggestions for a more precise input of problems 	<ul style="list-style-type: none"> - Shows detailed steps and solutions 	<ul style="list-style-type: none"> - The user can reenter recent problems to modify it - Can view detailed steps only when the user watched an advertisement - It can share solutions on social media and other platforms 	<ul style="list-style-type: none"> - Free to Install - Requires premium upgrade for steps on every problem - Requires Internet Connection 	<ul style="list-style-type: none"> - Subjects are separated from one another - Can solve common solid figures - Equipped with Scientific Calculator
7. Socratic 	<ul style="list-style-type: none"> - Can solve arithmetic, algebra, trigonometry, and calculus. - Cannot solve matrices, limits and statistics. - Can solve word problems (math and other disciplines such as physics) 	<ul style="list-style-type: none"> - The user can input problems through photo and voice. 	<ul style="list-style-type: none"> - Shows similar questions and video tutorials from the internet - The app is directly connected with other math app so the user may have a variety of solutions. The apps include Mathway, Cymath, MathPapa and Wolfram Alpha 	<ul style="list-style-type: none"> - Some of the text are difficult to read because of the color/theme of some text 	<ul style="list-style-type: none"> - Free to Install - Requires Internet Connection 	<ul style="list-style-type: none"> - Directly connected with the online resources
8. WolframAlpha 	<ul style="list-style-type: none"> - Can solve arithmetic, algebra, trigonometry and calculus. 	<ul style="list-style-type: none"> - The user can input problems through keying - Difficulty 	<ul style="list-style-type: none"> - Shows detailed steps and solutions and what methods 	<ul style="list-style-type: none"> - The user can search mathematical concepts and principles - Saves all 	<ul style="list-style-type: none"> - Paid application - Requires internet connection for it to be 	<ul style="list-style-type: none"> - There are sample problems available

	- Cannot solve limits, and statistics.	in the input of complex expressions for the user can only input in a linear manner	are taken to solve the problem	solved problems - It can share solutions on social media and other platforms	used	
9. Cymath 	- Can solve arithmetic, algebra, trigonometry and calculus. - Cannot solve limits, and statistics.	- The user can input problems through scanning, or keying	- Shows detailed steps and solutions and what methods are taken to solve the problem	- Saves all solved problems (for a fee)	- Free to Install - Some features such as saving and noting on solutions can only be accessed through premium version	- There are references and practice problems available - There is a blog that features question of the week



Figure 2. Summary of the Mean Ranks with Graph of Mean Ranks in terms of the Overall Features

CONCLUSION

The possible benefits and drawbacks of using mobile apps in the teaching-learning process are determined by the application, the goal of usage, student use, and the teacher's capability to incorporate the mobile application into the teaching-learning process.

In this study, each mobile application is quantitatively and qualitatively evaluated using six (6) different criteria to determine which mobile applications are best suited for the following factors: solving features, input capability features, learning guide features, convenience features,

accessibility features, and supplementary content features. This study suggests using certain application based on the criteria's as follows.

In terms of solving features, Mathway can solve all criteria set by the researcher. The questions came from subjects arithmetic, algebra, trigonometry, calculus and statistics. The advantage of using Mathway, and its statistically similar apps, include faster computation and greater productivity as the user can practically solve any problem from the subjects considered. On the other hand, this application can be an instrument for misuse and can be exploited for its solving functions.

In terms of input capability features, Microsoft Math Solver have 4 different ways to input the problem. The advantage of using Microsoft Math Solver gives the greatest variation among the considered math apps, so that the user can have an option depending on the problem on how to input it. The more complex the problems are, the better it is to use scanning or picture input rather than keying and handwriting.

In terms of learning guide features, Socratic have direct access to the internet and shows similar questions or video tutorials from the internet. This app is also directly connected with other math app so the user may have a variety of solutions. This gives advantage for that user who wants to practice problems simultaneously while looking at different methods of solutions.

In terms of convenience feature, Microsoft Math Solver can save all solved problems, share solutions on social media and other platforms, and can bookmark selected problems to easily find it. The app also doesn't show any advertisement for an uninterrupted use. On the other hand, this also gives easy access to sharing answers and solutions in the exams or quizzes.

In terms of accessibility features, MalMath is the only math application in which all of the contents are free to access and can be used offline. This gives advantage for users who cannot afford to pay a certain amount or have limited access to the internet. Thus, ensuring a continuous learning with the use of a math app during unwanted or restricted situations.

In terms of supplementary features, WolframAlpha contains almost all listed supplementary contents in the criteria except the conversion of units feature. These supplementary contents can add value to the knowledge gained by the student in solving specific problems.

Overall, Microsoft Math Solver ranked the highest among the considered math apps. But statistically, this study suggests that it does not differ from WolframAlpha, Mathway, PhotoMath, Cymath, Socratic, and Malmath.

The goal of such math apps must be limited only to assistance and further improvement of the mathematical literacy of the users. Using it for unacceptable academic behaviors such as cheating is highly discouraged

Recommendations

The use of math applications in the teaching-learning process is not just dependent on solving features, input capability features, learning guide features, convenience features, accessibility features, and supplementary content features. Additional criteria can be considered for evaluation. Continuous study is also encouraged since technology is always progressing and developing, which may be used to benefit instructors and students. The researcher generally recommends that:

1. In the future, surveys should be performed to determine which subjects and criteria should be included in the evaluation of various math apps.

2. With the use of mobile applications, mathematics instructors must prioritize the production of teaching materials and the selection of appropriate teaching techniques.
3. Mathematics instructors should be sent to seminars, workshops, and conferences to improve their teaching skills so that they may be more creative in making learning more productive and enjoyable.
4. Students should have consistent access to learning tools to improve their mathematical reasoning, reasoning, problem-solving, and communication abilities.
5. The school's administration should encourage and embrace the usage of mobile applications in the classroom to the greatest degree possible. For pupils to be globally competitive, the instructor must also be up to date on current events.

Mobile Applications in Instruction

Faster computations, greater productivity, utilization of online and supplementary resources, and familiarization with alternative answers and approaches are among possible benefits of using mobile math applications. While the most prevalent possible drawbacks of utilizing mobile math applications are misuse of its functions, including cheating, a drop in study habits because students are convinced that math apps help handle their tasks, and exploitation of mobile application capabilities.

Knowledge of the capabilities of these mobile applications that are incorporated into the teaching-learning process can assist instructors in planning, developing, and upgrading their teaching approaches to maximize possible advantages while minimizing downsides.

The teacher can consider a variety of math apps that can be found on the internet. The question rises on which mobile application/s are most suited to assisting teachers in enhancing and enriching their assessments in order to successfully aid the teaching-learning process in mathematics.

If the teacher is looking for learning and supplementary concepts, consider using WolframAlpha and Socratic. WolframAlpha contains almost all listed supplementary contents in the criteria except the conversion of units feature. These supplementary contents can add value to the knowledge gained by the student in solving specific problems. Socratic have direct access to the internet and shows similar questions or video tutorials from the internet. This app is also directly connected with other math app so the user may have a variety of solutions. This gives advantage for those students who wants to practice problems simultaneously while looking at different methods of solutions.

If the specific problems for teaching or assessment are pre-made by the teacher, math app such as Mathway and statistically similar apps can help the teacher be productive by aiding in coming up with a solutions and methods.

If the teacher wants new questions related to specific topics, consider using Malmath. This app is equipped with a problem generator for algebra, trigonometry, limit, differentiation, and integral calculus.

Knowing the capabilities of these math apps, it's important to improve the assessments given for the students. The teachers are encouraged to give assessments that allows the students to perform application of the concepts rather than simply giving them equations or problems that are practically solvable by such mobile applications. Giving one expression or one equation problems easily gives away the purpose of learning. With a simple click or typing of problems,

the student can solve the problems without effort exerted and may take the lesson for granted as the math apps can solve those problems easily.

Mobile Applications in Learning

Remember that the math apps are merely a tool to assist learning and a supplement for additional knowledge for improving the student's mathematical literacy and problem-solving abilities. Proper guidance from the teacher is still the best method to instill knowledge and comprehension.

Before encouraging the students to use math apps with substantial capabilities, make sure that basic principles and foundations are already discussed in the class so that the student already have the foundational idea and the math apps' purpose are merely to guide them for more complex problems.

For solving problems that are mostly arithmetic in nature, consider using MyScript Calculator. As it can easily input the problem through handwriting.

For solving problems that are algebraic, trigonometric, and calculus based, consider using Mathway and statistically similar math apps.

However, for students to learn, it is important for an app that can solve equation and problems to be equipped with learning guide features and supplementary content features. Fortunately, in this study, there are math apps that contain these features. Microsoft Math Solver, the highest mean ranked app in this study, can solve majority of the problems in the criteria and shows detailed steps, solutions and methods taken to solve the problem. Also, when solving a problem, it shows the graph, similar problems, video tutorials, related concepts, worksheets from web, and similar problems from web. If the student doesn't want to solve a problem but only to learn concepts, it is suggested to use WolframAlpha contains almost all listed supplementary contents in the criteria except the conversion of units feature.

Additionally, take note of the accessibility features of the math apps, some requires payment for a full feature, others require a stable internet connect. Most of the students in the Philippines nowadays struggle with meeting these requirements in utilizing math apps in education. Thus, it is recommended to use math apps that are free to install and does not require internet connection as a backup for most of the situations. Malmath is a good back up application as it can also solve majority of questions in the criteria, shows a detailed solution and can be used offline.

In summary, utilization of math apps depends on the needs of the students and capability of the teachers to facilitate its utilization. All math apps have their own strengths and weaknesses, so are the students. Math apps are a powerful tool in assisting teachers in enhancing and enriching their assessments. Furthermore, it can be utilized to assist learners in improving their mathematical literacy and problem-solving abilities.

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