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Maple v.18 software in the learning of the subject Mathematics II in students of the Faculty of Mining, Geology and Metallurgy Engineering, semester 2024-I-Unasam- Huaraz, 2024

[El software Maple v.18 en el aprendizaje de la asignatura Matemáticas II en estudiantes de la Facultad de Ingeniería de Minas, Geología y Metalurgia, semestre 2024-I-Unasam- Huaraz, 2024]

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Resumen

El Software Maple V.18 es un recurso didáctico que permite mejorar el aprendizaje de la matemática en estudiantes universitarios. El objetivo de esta investigación fue determinar la influencia del software Maple V.18 en el aprendizaje del curso Matemática II en estudiantes de la Facultad de Ingeniería de Minas, Geología y Metalurgia de la UNASAM, durante el semestre 2024-I. Se trató de un estudio aplicado, con diseño cuasi experimental y perspectiva cuantitativa. La muestra se compuso de 31 alumnos a los que se les realizaron un pretest y un postest, ambos validados por dos especialistas. El aprendizaje en Matemática II y el uso del software Maple V.18 fueron las variables que se examinaron. Se plantearon una hipótesis alterna y una hipótesis nula. Los resultados, que se obtuvieron y que fueron evaluados mediante la prueba T de Student, evidenciaron una influencia significativa del software en el aprendizaje del curso Matemática II, por lo que se acepta la hipótesis alterna. En conclusión, el uso del Software Maple V.18 contribuye de manera significativa a mejorar el aprendizaje del curso Matemática II en los estudiantes de la Facultad de Minas, Geología y Metalurgia

Palabras clave: Maple.V. 18, rendimiento académico, aprendizaje, trabajo en equipo y motivación.

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Abstract

Maple V.18 software is a teaching resource that enhances mathematics learning for university students. The objective of this research was to determine the influence of Maple V.18 software on the learning of the Mathematics II course among students in the Faculty of Mining, Geology, and Metallurgy Engineering at UNASAM during the 2024-I semester. This was an applied study with a quasi-experimental design and a quantitative approach. The sample consisted of 31 students who completed a pre-test and a post-test, both validated by two specialists. Learning in Mathematics II and the use of Maple V.18 software were the variables examined. An alternative hypothesis and a null hypothesis were formulated. The results, obtained and evaluated using Student's t-test, demonstrated a significant influence of the software on the learning of the Mathematics II course; therefore, the alternative hypothesis was accepted. In conclusion, the use of Maple V.18 software significantly contributes to improving the learning of the Mathematics II course in students of the Faculty of Mines, Geology and Metallurgy

Keywords: Maple.V. 18, academic performance, learning, teamwork and motivation.

I. Introduction

It is essential to equip university students with mathematical competencies, skills, and abilities in times of intense global competition and widespread use of online classes, a consequence of the global pandemic. In particular, it is important that they have a strong grasp of definite and indefinite integrals, as well as their applications and use in polar coordinates, so they can develop their individual and collective skills. This will allow them to understand the role of integral knowledge in their professional training and in solving contextual problems. However, learning mathematics, and specifically the knowledge of integrals, presents challenges that any higher education student may encounter. Internationally, students often demonstrate deficiencies in applying integration methods to obtain the indefinite integral of a function, and a considerable percentage of students are unaware of the application or usefulness of definite and indefinite integrals in solving problems encountered in society (Barroso et al., 2016, pp. 24-25). Scientific literature indicates that the challenges faced in the teaching and learning process of integral calculus occur not only locally but also globally, as demonstrated by research conducted in various countries. Globally, the most common obstacles to students' learning of integral calculus have been identified as the application of an axiom-based approach, the use of algorithms, and the presentation of routine examples. Mathematics could be considered a set of universally valid rules and formulas. Due to these challenges, we found it necessary to dedicate extra or extracurricular hours to teaching integral calculus to Systems and Computer Engineering students, using a more dynamic methodology and some open-source software to improve their learning. This approach, however, is often outside the students' daily lives and familiar environments, whether they are students or teachers (Cordero, 2005; Moreno, 2018).

The teaching and learning process for integral calculus, as implemented in the Mathematics II course, presents a challenge at universities across the country. It is evident that current teaching and learning methods rely on the use of a blackboard, markers, and lectures. In the latter case, students listen to explanations without actively participating in the learning process. This demonstrates that the methods and resources currently employed are inadequate and outdated, turning students into mere information recyclers, which contributes to the high failure rate. Therefore, it is essential that mathematics instructors incorporate mathematical software, primarily Maple V.18, to enhance their teaching effectiveness. The School of Mathematics, part of the Faculty of Sciences at the National University "Santiago Antúnez de Mayolo," is responsible for delivering mathematics courses in all the university's professional schools. One of these courses is Mathematics II, which was taught this semester (2024-II) to students specializing in Mining Engineering, within the Faculty of Mining, Geology, and Metallurgy Engineering.

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Experience gained over several years of teaching this course has shown that, due to the rigor and level at which the topics are developed, students from various professional schools exhibit the following learning difficulties: deficiencies in the concepts of indefinite integrals, including the conceptual definition of the indefinite integral, its properties, and problem-solving methods such as integration by substitution, integration by parts, trigonometric integration, trigonometric substitution, and partial fractions. They also demonstrate learning difficulties in the concepts of definite integrals, sums as limits, the conceptual definition of calculus theorems, mean value theorems, and their respective solutions. Finally, they exhibit learning difficulties in the topics of integration with polar coordinates, areas and plane regions, and volumes of solids. This is why we set out to implement Maple V.18 software, whose purpose is to improve the learning of the Mathematics II course for Mining Engineering students. These students must ensure that the mathematical skills acquired during their first year of studies in courses such as basic mathematics and Mathematics I (differential calculus) are sufficient to avoid learning difficulties when they take Mathematics II. Given these considerations, we find it imperative to pose the following question: How does Maple V.18 software influence the learning of the Mathematics II course for students of the Faculty of Mining, Geology, and Metallurgy Engineering at UNASAM during the 2024-I semester? To provide a tentative answer to our research problem, the following research hypothesis was considered: There is a significant influence of Maple V.18 software on the learning of the Mathematics II course for students of the Faculty of Mining, Geology, and Metallurgy Engineering at UNASAM during the 2024-I semester. which will be verified by testing the hypothesis.

Regarding the research topic, there are some existing research studies (correlational and quasi-experimental) that are relatively related to this work, specifically studies on Maple V. 18 software and mathematics II learning, which were necessarily taken into account in this research.

Alves (2022), in his research paper, “O emprego do software Maple como ferramenta educacional de ensino-aprendizagem de calculus differentiale e integral por meio do ensino humanos, formato flex” (January 2022), analyzes the contributions of using Maple software in the teaching and learning of differential and integral calculus through the Hybrid Teaching Flex format in a university extension course. The course was developed at the Fundação Universidade Federal de Rondônia, Ji-Paraná campus (RO), in the second semester of 2021. The research stems from the researcher's desire to deepen knowledge about the teaching and learning of Calculus through the development and application of a methodological proposal using Maple and Hybrid Teaching, in light of Activity Systems Theory and the Human Beings-with-Media Construct (BORBA, 1999). The purpose of this research was to demonstrate that Maple played a leading role, acting as a teacher/mediator in the course. We considered the findings from Vargas's (2022) research, in his master's thesis, "Application of Maple Software and its Influence on Academic Performance in Differential Calculus, in First-Year Students of the Mathematics Program at the Universidad Nacional Pedro Ruiz Gallo 2019-II." The purpose of this research was to determine how the use of Maple software affects the academic performance of first-year mathematics students at the Pedro Ruiz Gallo National University during the 2019-II semester. This applied study employed a quasi-experimental design, and students underwent a pre- and post-test covering the procedural, attitudinal, and conceptual dimensions of learning. The study concluded that Maple software has a significant impact on academic performance in the differential calculus course, as it enables the resolution of various applications, such as limits, continuity, graphing functions, and derivatives, using relevant properties, thus aligning with our research proposal.

Another finding by Ramírez (2022) aimed to determine the extent to which the Maple Program improves academic performance in mathematics courses for first-year Civil Engineering students at the National University of Cajamarca during the 2019-I academic semester. The research employed an applied approach with a quasi-experimental design. The sample consisted of 60 students, and the instrument used was the Educational Assessment test (pre-test and post-test).

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The Kolmogorov-Smirnov normality test was performed, indicating a lack of normality. The Wilcoxon signed-rank test was then used for hypothesis testing, concluding that the descriptive and inferential statistical results clearly demonstrate and confirm the importance of implementing the Maple Program to improve academic performance in mathematics among first-year Civil Engineering students at the National University of Cajamarca during the 2019-I academic semester. This finding is consistent with the work of Delgado (2018). The objective was to determine the effect of using the MAPLE software on the academic performance of undergraduate students enrolled in Calculus II during the 2018-II semester. The results indicate that the use of this software had a positive effect on the academic performance of undergraduate students in the Calculus II course. A quantitative approach was used, and the research employed a quasi-experimental design. The sample comprised Calculus II students, including both morning (52 students) and evening (52 students) students. The assessment tool was used twice, yielding pre-test and post-test results that measured each student's academic performance. The results confirmed that the use of MAPLE software had a positive effect on the academic productivity of third-year undergraduate students in the Calculus II course at the Engineering School of Norbert Wiener Private University.

Some concepts about Maple V. 18 software: Maple is an algebraic or symbolic computation system. Both expressions refer to Maple's ability to manipulate information as we do when performing analytical mathematical calculations. While traditional math programs require numerical values for each variable, Maple preserves and manipulates expressions and symbols. These symbolic capabilities make it possible to obtain precise analytical solutions to mathematical problems: for example, it can calculate limits, derivatives, and integrals of functions, solve systems of equations exactly, find solutions to differential equations, and so on. Complementing the symbolic operations is a wide range of graphical routines that allow the visualization of complex mathematical information, numerical algorithms that provide solutions with arbitrary precision to problems whose exact solution is not computable, and a complete and understandable programming language that allows the user to create their own functions and applications (Martínez, 2016). Maple's interface looks very similar to that of other programs used in graphical operating systems and allows access to all the manipulator's functions and capabilities. Basically, what appears when you launch Maple (by double-clicking its icon, for example) is a more or less conventional window containing what is called a "worksheet." The flexibility of the worksheet allows for both research into mathematical ideas and the creation of sophisticated technical articles (Martínez, 2016). In this way, Maple offers great potential for application and use in research, professional work, and, of course, in teaching mathematics.

Similarly, some conceptions of learning, such as those of Alonso and Gallegos (2003), define learning as a “process of acquiring a relatively lasting disposition to change perception or behavior as a result of experience.” Soto and García (2013) define it as: “The dialectical process of appropriating the content and forms of knowing, doing, living together, and being constructed in socio-historical experience, in which, as a result of the subject's activity and interaction with others, relatively lasting and generalizable changes occur, allowing them to adapt to reality, transform it, and grow as a personality.” Velázquez et al (2011 p 52) defined reflective learning as: "[...] that in which the subject appropriates the historical-social experience accumulated during the development of humanity, understood as teaching content, when faced with the formulation and solution of problems that are derived from the content, through the implementation of an intense reflective activity that allows him to establish his own procedures and solution strategies, supported by his experiences and life events, to find the corresponding answers, which favors the appropriation of the content, contributing his resources, enriched in the interaction with others, transforming himself and the reality in which he acts, all of which favors his integral development as a personality"

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II. Materials and Methods

Type of research

Due to its approach, it is a quantitative investigation (Hernández, Fernández, & Baptista, 2014). The quantitative approach is sequential and evidentiary; it begins with an idea that is gradually narrowed down, and once delimited, research objectives and questions are derived, the literature is reviewed, and a theoretical framework or perspective is constructed.

Due to its utility, it is an applied investigation (Carrasco, 2009, p. 43). Applied research is distinguished by its well-defined, immediate practical purposes; that is, it investigates to act, transform, modify, or produce changes in a specific sector of reality. Its purpose is to solve a practical problem. The contextualization of mathematics as a didactic strategy influences the learning of mathematics in students of the Business Administration program at UNASAM. Due to its depth, it is an explanatory-level investigation (Niño, 2011, p. 34). Explanatory or causal research answers the question, "Why?" This research seeks to uncover the causes of why a particular event or phenomenon under study behaves in a certain way, or why its existence or nature is conditioned by it. The research is explanatory because it aims to explain how the contextualization of mathematics as a teaching strategy influences the learning of mathematics in students of the Business Administration program at UNASAM.

Research Design

The research design can be defined as a structured or schematic organization adopted by the researcher to relate and control the study variables. "It serves as a guiding and restrictive instrument for the researcher; in this sense, it becomes a set of guidelines under which an experiment or study will be conducted" (Hernández, Fernández, and Baptista, 2014). Statistical methods will be used to analyze the learning of mathematics in the experimental and control groups.

This study will be quasi-experimental. Cresswell (2009) defines quasi-experimental research as that which uses a convenience sample, since the researcher must use pre-existing groups (e.g., a classroom, an organization, or a family) or volunteers. Therefore, this type of procedure is used when the subjects to be studied cannot be randomly assigned. In the Mining Engineering program, the groups or sections of the Mathematics II classes are already formed by the School Administration, and no randomization can be used among the subjects to be studied. Pre-established sections will be used.

To achieve the stated objectives and to analyze the validity of the formulated hypothesis, the research design is experimental, specifically quasi-experimental, and its structure is as follows:

EG: O_1 ------------------X---------------------O_2
CG: O_3 --O_4

Where:
EG: Experimental group (single)
CG: Control group
O1: Pre test
O3: Pre test
O2 : Pos test
O4 : Pos test
X: Experiment (Software Maple V. 18)

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Population
In this research study, the study population will consist of students from the Faculty of Administration and Tourism, enrolled in the Administration program, from the first semester of 2022-I, representing a total of 96 students. Only those students who completed their graded assignments and midterm exams will be included in the study population.

Table 1. Population and sample

Professional School	Group (N)	Sample (n)
Mining	31 Experimental	31
Mining	30 Control	30
Total	61	61

Source: General Studies Office (OGE)

Instrument
Hernández Sampieri and Mendoza (2018) argue that a technique is a set of mechanisms, means, and systems used to direct, collect, preserve, reprocess, and transmit data. Based on this argument, the survey technique will be applied, using a questionnaire as the instrument. This questionnaire will contain simple questions that will allow us to collect data on the influence of Maple V. 18 software as a didactic resource in the learning of the Mathematics II course, specifically integral calculus, in Mining Engineering students.

The following instruments were used for data collection:
- Pre-test: This will be administered at the beginning of each unit and will serve to diagnose and analyze the prior knowledge of the control and experimental groups.
- Post-test: This will be administered at the end of the unit after the application of Maple V.18 software to the experimental group.

Procedure

a) The teaching-learning sessions will be developed taking into account the content established in the syllabus.
b) Maple V.18 software will be administered to the students in the experimental group to determine their learning in Mathematics II.
c) Written tests will be administered at the end of each unit to determine the academic performance of the students in the study group.
d) Finally, the academic performance of the students in both groups will be compared, taking into account the results obtained in the pre-test and post-test, and in each of the tests for the four units.

The results obtained will be processed in quantitative frequency tables with their respective percentages and corresponding graphs.
The analysis and interpretation technique will be based on the results obtained from the processed information.

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III. Results

In accordance with the objectives of this research, the results are presented in the table, reflecting the intervention carried out by the teacher-researcher over 14 weeks using the pre-test and post-test.

Table 2: Statistical indicators of pre-test scores for the control and experimental groups in mathematics learning, Shapiro-Wilk test, to establish normality

	Statistics	gl	p-value
Notes on the Indefinite Integral	,944	31	,109
Notes on the Definite Integral	,953	31	,193
Notes on Applications of the Definite Integral	,944	31	,104
Notes on Integrals in Polar Coordinates	,944	31	,106
Pretest Notes	,934	31	,056
Posttest Notes	,945	31	,113

Source: researcher's scores record

Table 2 shows that the Shapiro-Wilk test yielded a p-value > 0.05, therefore we conclude that the scores follow a normal distribution.

This table also shows differences in the measures of central tendency (averages) between the control and experimental groups, with the control group having the highest averages. In contrast, the experimental group is more homogeneous in terms of data dispersion than the control group, but the variability is small in both cases.

Table 3
Average scores on the Pre-Test, Indefinite Integral, Definite Integral, Applications of the Definite Integral, Integral in Polar Coordinates, and Post-Test for student learning in the Mathematics II course.

	N	Average Score	Standard deviation
Pretest Notes	31	3,42	1,803
Indefinite Integral Notes	31	8,16	1,772
Definite Integral Notes	31	9,13	1,688
Applications of the Definite Integral Notes	31	10,10	1,599
Integral in Polar Coordinates Notes	31	10,55	1,841
Posttest Notes	31	10,29	1,371

Source: researcher's scores record

Table 3 shows that the average Pre-Test score was 3.42 with a standard deviation of 1.803. Comparing this with the average scores and standard deviations for Indefinite Integral (8.16; 1.772), Definite Integral (9.13; 1.688), Applications of the Definite Integral (10.10; 1.599), Integral in Polar Coordinates (10.55; 1.841), and Post-Test (10.29; 1.371), the scores improved significantly after applying Maple V.18 software. Therefore, we can conclude that learning with Maple V.18 software significantly improves performance in the Mathematics II course.

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Hypothesis Test

Table No. 4
Student's t-test of Pre-Test scores and Indefinite Integral scores in the Mathematics II course.

	Media	t	g.l	p- evalue
Score Pre Test- Score Indefinite Integral	-4,742	-12,138	30	,000

Source: researcher's scores record

Ho: Maple V.18 software does not significantly influence the learning of indefinite integrals in mining engineering students.
Ha: Maple V.18 software significantly influences the learning of indefinite integrals in mining engineering students.
In Table 4, performing the statistical analysis with the paired-samples t-test comparing the pre-test scores and the indefinite integral scores yielded a significance level ($p < 0.05$), confirming that Maple V.18 software significantly influences the learning of indefinite integrals in the Mathematics II course for mining engineering students with 95% confidence.

Table No. 5
T-test of pre-test scores and definite integral scores in the Mathematics II course

Score	Media	t	gl	p-value
Score Pre Test – Score definite Integral	-5,710	-15,869	30	,000

Source: researcher's scores record.

Ho: Maple V.18 software does not significantly influence the learning of the definite integral in mining engineering students.
Ha: Maple V.18 software significantly influences the learning of the definite integral in mining engineering students.
In Table 5, performing the statistical analysis with the paired-samples t-test comparing the pre-test scores and the definite integral scores yielded a significance level ($p<0.05$), confirming that Maple V.18 software significantly influences the learning of the definite integral in the Mathematics II course for mining engineering students with 95% confidence.

Table No. 6
T-test of pre-test scores and scores on Applications of the Definite Integral in the Mathematics II course

	Media	T	gl	p-value
Score Pre test – Score Post Test	-6,677	-22,117	30	,000

Source: researcher's scores record.

H0: Maple V.18 software does not significantly influence the learning of Applications of the Definite Integral in Mining Engineering students.
Ha: Maple V.18 software significantly influences the learning of Applications of the Definite Integral in Mining Engineering students.
In Table 6, performing the statistical analysis with the paired-samples t-test comparing the Pre-Test scores and the scores on Applications of the Definite Integral, a significance level ($p<0.05$)

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is obtained, confirming that Maple V.18 software significantly influences the learning of Applications of the Definite Integral in the Mathematics II course for Mining Engineering students with 95% confidence.

Table No. 7
T-test of Pre-Test scores and scores on Integrals in Polar Coordinates in the Mathematics II course

	Media	t	gl	p-evalue
Pretest - Integral in polar coordinates	-7,129	-21,797	30	,000

Source: Researcher's notes

H0: Maple V.18 software does not significantly influence the learning of integrals in polar coordinates among mining engineering students.
Ha: Maple V.18 software significantly influences the learning of integrals in polar coordinates among mining engineering students.
In Table 7, performing the statistical analysis with the paired-samples t-test comparing the pre-test scores and the scores for integrals in polar coordinates yielded a significance ($p<0.05$), confirming that Maple V.18 software significantly influences the learning of integrals in polar coordinates in the Mathematics II course for mining engineering students with 95% confidence.

Table No. 8
T-test of pre-test and post-test scores in the Mathematics II course

	Media	t	gl	p-evalue
Pretest – Postest	-6,871	-24,443	30	,000

Source: Researcher's notes

H0: There is no significant influence of Maple V.18 software on the learning of the Mathematics II course in students of the Faculty of Mining, Geology and Metallurgy Engineering, semester 2024-I-Unasam-Huaraz, 2024
Ha: There is a significant influence of Maple V.18 software on the learning of the Mathematics II course in students of the Faculty of Mining, Geology and Metallurgy Engineering, semester 2024-I-Unasam-Huaraz, 2024.
In Table 7, performing the statistical analysis with the paired-samples t-test comparing the Pre-Test and Post-Test scores yielded a significance ($p<0.05$), confirming that Maple V.18 software significantly influences the learning of the Mathematics II course in students of the Mining, Geology and Metallurgy Engineering program, semester 2024-I-Unasam-Huaraz, 2024. 95% confidence

IV. Conclusions

- Performing a statistical analysis using the paired-samples t-test comparing pre-test and post-test scores yielded a significant result ($p < 0.05$), confirming that Maple V. 18 software significantly influences the improvement of learning in the Mathematics II course for Mining, Geology, and Metallurgy Engineering students in the 2024-I semester at UNASAM-2024, with 95% confidence.

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- Performing a statistical analysis using the paired-samples t-test comparing pre-test scores and scores on the Indefinite Integral also yielded a significant result (p < 0.05), confirming that the learning of the Indefinite Integral for Mining, Geology, and Metallurgy Engineering students significantly improves with Maple V. 18 software, with 95% confidence. • Performing a statistical analysis using the paired-samples t-test comparing the pre-test scores and the definite integral scores yielded a significant result (p < 0.05), confirming that the learning of the definite integral among Mining, Geology, and Metallurgy Engineering students using Maple V. 18 software significantly improves with 95% confidence.
- Performing a statistical analysis using the paired-samples t-test comparing the pre-test scores and the definite integral applications scores yielded a significant result (p < 0.05), confirming that the learning of the definite integral applications among Mining, Geology, and Metallurgy Engineering students using Maple V. 18 software significantly improves with 95% confidence.
- Performing the statistical analysis with the T-student test for related samples comparing the Pre Test scores and the integral scores in polar coordinates, a significance (p<0.05) is obtained, confirming that the learning of the Application of the Definite Integral in Mining Engineering, Geology and Metallurgy students with Maple V. 18 Software improves significantly with 95% confidence.

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- To the Dean of the Faculty of Mining, Geology and Metallurgy Engineering at UNASAM, for allowing us to apply our data collection instruments to students in the Mining Engineering program.
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Annex 1. Questionnaire

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PRE-TEST AND POST-TEST RESEARCH INSTRUMENT

Instructions:
This questionnaire refers to the Academic Reinforcement Workshop in the learning of integral Calculus in students of the professional career of Systems Engineering and Computer Science, as it refers to indefinite integral, definite integral and applications of the definite integral.
You have 120 minutes to answer the questionnaire, and consider that the development of the test is not decisive for the course average. It will be useful to the extent that you are sincere in your answers, having a rating of two points per question.

N°	OPINIONS
INDEFINITE INTEGRAL	
1	What do you understand by an indefinite integral?
2	In what cases can I apply the integration by parts method?
3	Are Trigonometric Integration and Integration by Trigonometric Substitution the same?
4	Calculate $\int \left(x-\sqrt{x}+1\right)\left(\sqrt{x}+1\right)dx$
DEFINITE INTEGRAL	
5	Calculate $\int_{1}^{3} \frac{x^2}{\sqrt{2x^3+7}}dx$
6	What is the difference between an indefinite and a definite integral?
7	Calculate $\int_{0}^{1} \frac{e^x}{e^x+e^{-x}}dx$
8	Calculate $\int_{0}^{1} \frac{arcsen\sqrt{x}}{\sqrt{x}\,(x-1)}dx$
APPLICATIONS OF DEFINITE INTEGRAL	
9	Calculate the area of the figure limited by the curves $y=x^2 \quad \wedge \quad y=\frac{x^3}{3}$
10	Calculate the area of the figure limited by the curves $y=4-x^2$ and the x axis, when rotating around the x axis

¡Thank you for your collaboration!