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Education On Building A Flat In (Determinants Of Matrix, Definite Integrals, And Discriminatory)

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Abstract.

This paper examines the calculation of plane areas using three mathematical approaches: matrix determinants, definite integrals, and discriminants. Although determinants are commonly studied in linear algebra and definite integrals in calculus, both concepts are closely related in solving area problems. The study aims to compare the results, efficiency, and applicability of these methods for calculating the areas of closed polygons, including triangles, squares, parallelograms, kites, and trapezoids, as well as regions bounded by the intersection of two quadratic functions. This research employs a literature review method through the analysis of books, journal articles, and other scientific references relevant to matrix determinants, definite integrals, and discriminants. The findings indicate that the determinant and definite integral methods produce identical area values for linearly bounded polygons, while the discriminant and definite integral methods yield equivalent results for regions formed by the intersection of quadratic functions. The determinant and discriminant methods offer greater computational efficiency in specific cases, whereas the definite integral method provides broader applicability for both linear and nonlinear boundaries. These findings contribute to mathematical visualization and can be utilized as instructional materials to strengthen students' understanding of area concepts in linear algebra and calculus courses.

Keywords: matrix determinant, definite integral, discriminant, area calculation, mathematical visualization.

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INTRODUCTION

The measurement of the area or geometric plane is one of the main foundations in the development of mathematics and its application in the real world. Area is a two-dimensional space within a region (de Walle 2008). 'Region' in mathematics is a building consisting of a flat building and a part of the plane in it(Negoro and Harahap 1985). From the era of classical geometry to the current digital age, the need to calculate the area of an object has continued to grow. This development can be seen in the mathematics curriculum at the educational level, the higher the level of education, the more complex the concept of broad calculation (the object that is calculated has regular and irregular shapes or undergoes complex spatial transformations). To overcome these limitations, integral calculus is present as a scientific solution that is able to calculate the area under the curve with the principle of accumulation of small elements (infinitesimal). Through integrals, of course, mathematics is able to model and calculate the area of an irregular two-dimensional plane precisely by dividing objects into infinite partitions.

On the other hand, the development of linear algebra introduced matrices as a tool for manipulating the coordinates of space through geometric transformations, In this context, the determinants of a square matrix are not simply abstract scalar values. Determinants have an intrinsic geometric significance as a factor of the scale of broad change. When a coordinate field is transformed by a matric, the determinants of that matrix determine how much the area of the original field will enlarge, shrink, or reverse. Furthermore, the determinant can also directly calculate the area of a coordinate polygon without requiring a complicated integration process(Radic 2008).

Some forms of coordinate polygons (such as triangles, squares, parallelograms, kite trapezoids) as well as many other flat planes such as circles and planes formed by the intersection of two functions at two points that form a quadratic function. To calculate the area of a flat plane, for example a square, a standard formula that has been studied since high school is often used, namely length multiplied by width, but what becomes a problem if the values of length and width are explicitly not determined but what is determined is the angular coordinates of the existing flat plane, this becomes a work that takes time to analyze with several approaches in determining the results of the area calculation.(Windarni, Setiawan, and Rahmatalia 2023)

The approach that can be used to solve the problems mentioned above is by using the concept of determinants of the 3x3 order matrix, integral certainty, and discriminatory. To use the concept of matrix determinants, it is necessary to know the angular points of the flat plane in question, which can be formed as elements in a matrix of 3x3 order, that is, using three angular

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points of the formed polygonal plane so that the determination of the area can be calculated. Meanwhile, to use the concept of a certain Integral, it is necessary to know the boundary of the flat plane formed such as its function and boundary point, while to use the concept of discrimination, it is necessary to know the intersection point that forms the quadratic function.(Dewi 2018)

Although these two concepts are often taught separately in the mathematics-determinant curriculum in linear algebra and integrals in calculus, they are very closely related in analyzing broad concepts. Therefore, this *paper* is compiled to compile several broad calculation concepts with the determinant approach of matrices and integral operations. This holistic understanding is expected to provide a new perspective in mathematical visualization and computational efficiency(Alam 2023). A paper relevant to this paper calculates the area of the inscription in several methods, namely the matode scanning directly on the inscription, the multi-degree interpolation method, and with a geometric approach. (Laisouw and Sultan 2022) that broad calculations with the concept of discrimination are simpler but in limited cases. Meanwhile,(Djafar 2011) determined the area and equation of a flat plane using a matrix. (Laisouw and Sultan 2022) in a study on the comparison of area calculations using determinants and standard formulas that the calculation of area with determinants is more effective. Another relevance of broad content builds spatial skills, (Harris, Logan, and Lowrie 2023) the need to connect emerging spatial skills with mathematical content will support students to develop conceptual understanding in parallel with procedural constraints.

From the description above, the author feels that there is potential to be the focus of the study. (Sugiyono 2013) potential is something that if empowered will have added value. So the author highlights the potential of the writing pad, namely this "Deep flat field broad education (determinants of matrix, definite integrals and discriminatory)".

OVERVIEW OF CONNECTIVISM

Connectivism is a learning theory introduced by George Siemens and further developed by Stephen Downes to explain how learning occurs in the digital age. The theory argues that knowledge is distributed across networks consisting of individuals, information resources, technologies, and learning communities. Learning is therefore viewed as the ability to establish, maintain, and utilize connections among various sources of information. In connectivist learning, the capacity to identify relevant information and connect it with existing knowledge is considered more important than merely memorizing facts. This perspective is particularly relevant in higher

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education, where students are expected to access diverse learning resources and continuously update their knowledge in response to scientific and technological developments(Goldie 2016).

The principles of connectivism are reflected in this study through the integration of mathematical concepts from multiple disciplines, including linear algebra, calculus, and analytic geometry.(Hibi 2025) The article demonstrates that the concepts of matrix determinants, definite integrals, and discriminants can be connected to solve the same mathematical problem, namely the calculation of plane areas. This approach illustrates that knowledge is not acquired in isolation but is constructed through relationships among different concepts and learning resources. Through literature review, comparison of methods, and synthesis of theoretical perspectives, learners are encouraged to develop a broader understanding of mathematical problem-solving. Such an approach aligns with the connectivist principle that meaningful learning emerges when learners can recognize patterns, establish conceptual links, and integrate information from multiple knowledge networks(Yeni, Syamsudhuha, and Gamal 2015).

Furthermore, connectivism emphasizes the important role of technology in supporting learning processes and knowledge construction. In the context of this study, the recommendation to integrate mathematical visualization software and digital tools into future research reflects the connectivist view that technology functions as an extension of human cognition. Digital learning environments enable students to explore mathematical concepts interactively, collaborate with others, and access a wide range of academic resources beyond the classroom. Consequently, the application of connectivist principles in mathematics education can foster deeper conceptual understanding, enhance problem-solving abilities, and prepare students to engage effectively in an increasingly interconnected and technology-driven world.(Paul, Tanbir, and Sharma 2025)

OVERVIEW OF CONSTRUCTIVISM

Constructivism is a learning theory that emphasizes learners' active role in constructing knowledge through experience, exploration, and reflection. Developed primarily from the works of Jean Piaget and Lev Vygotsky, constructivism argues that knowledge is not passively received from teachers but actively built by learners through interactions with their environment. Learning occurs when individuals connect new information with prior knowledge, resulting in deeper conceptual understanding and meaningful learning experiences(Goldie 2016).

The article on plane area education reflects constructivist principles by encouraging learners to understand mathematical concepts through multiple approaches, including matrix determinants, definite integrals, and discriminants. Rather than relying on a single formula,

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students are guided to explore relationships among different mathematical representations to solve the same problem. Such learning experiences promote conceptual understanding because learners actively compare methods, analyze similarities and differences, and construct their own understanding of area calculations based on mathematical reasoning. Furthermore, the comparative analysis presented in the article allows students to develop higher-order thinking skills through problem-solving and critical evaluation of alternative methods. By investigating when determinant methods are more efficient than integrals and vice versa, learners engage in knowledge construction rather than simple procedural memorization. This approach aligns with constructivist pedagogy, which emphasizes inquiry, exploration, and reflective thinking as essential processes for meaningful mathematical learning(Arimbawa 2025)

SOCIAL LEARNING THEORY

Social Learning Theory, proposed by Albert Bandura, explains that learning occurs through observation, imitation, modeling, and interaction with others. According to this theory, individuals acquire knowledge and skills by observing behaviors, strategies, and outcomes demonstrated by peers, teachers, and other sources within their learning environment. Social interaction therefore becomes a critical element in the learning process because it facilitates the exchange and refinement of knowledge.(Bandura 1977)

Within the context of the article, social learning can be observed through the use of existing scholarly works, mathematical literature, and previous research findings as sources of learning. The author synthesizes concepts from textbooks, journal articles, and earlier studies to build a comprehensive framework for understanding area calculations using determinants, integrals, and discriminants. This process reflects the social nature of knowledge construction, where learning is influenced by contributions from a broader academic community.

In mathematics education, Social Learning Theory supports collaborative problem-solving and discussion-based learning activities. The article's comparative presentation of multiple methods encourages learners to engage in dialogue, evaluate alternative solutions, and learn from different perspectives. Through interaction with instructors, peers, and academic resources, students can strengthen their mathematical reasoning and develop a more comprehensive understanding of geometric concepts. Such collaborative learning environments are consistent with Bandura's view that knowledge develops through social observation and interaction(Irama, Sutarto, and RISAL 2024).

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THEORETICAL INSIGHT

Theoretical insight in this study emerges from the integration of concepts originating from different branches of mathematics, namely linear algebra, calculus, and analytic geometry. Traditionally, determinants, integrals, and discriminants are taught as separate topics; however, the article demonstrates that these concepts can be interconnected to solve a common mathematical problem. This interdisciplinary perspective provides a broader understanding of how mathematical theories complement one another in practical applications.(Skemp 1976)

A key theoretical contribution of the article lies in its demonstration that multiple mathematical methods can produce equivalent results while differing in computational efficiency and applicability. Determinants provide an efficient approach for polygons with straight boundaries, definite integrals offer flexibility for curved regions, and discriminants simplify calculations involving intersections of quadratic functions. This comparison highlights that mathematical problem-solving often requires selecting the most appropriate theoretical framework rather than relying exclusively on one method. The study therefore contributes to mathematics education by promoting conceptual integration rather than compartmentalized learning. Students are encouraged to recognize connections among mathematical concepts and understand the strengths and limitations of different approaches. Such theoretical insight supports the development of mathematical literacy, analytical thinking, and adaptive problem-solving skills that are essential in contemporary education.(Tall 2013)

CULTURAL EVOLUTION AND PRIMARY EDUCATION

Cultural evolution refers to the process through which knowledge, practices, values, and skills are transmitted and refined across generations. In educational contexts, schools play a significant role in preserving and developing cultural knowledge by introducing learners to established intellectual traditions while preparing them for future societal changes. Mathematics is one of the most important cultural achievements transmitted through formal education because it provides universal tools for reasoning, measurement, and problem-solving.(Tomasello 2009)

The article illustrates cultural evolution in mathematics education by presenting how area measurement has evolved from simple geometric formulas to more sophisticated approaches involving determinants, integrals, and discriminants. Historically, area calculations were limited to standard geometric formulas, but advances in mathematical knowledge have expanded the range of methods available for solving increasingly complex problems. Through education, these

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accumulated mathematical innovations are transferred from one generation of learners to the next. (Harris, Logan, and Lowrie 2023)

At the primary education level, understanding area concepts serves as a foundation for later mathematical learning. Introducing students to visual representations, geometric reasoning, and measurement concepts helps develop spatial thinking skills that can be expanded in secondary and higher education. The article's emphasis on visualization and multiple solution strategies supports contemporary educational goals that seek to develop both procedural competence and conceptual understanding from an early age

HIGHER EDUCATION SHIFT

The transformation of higher education in the twenty-first century has significantly influenced the teaching and learning of mathematics. Contemporary higher education no longer emphasizes the transmission of isolated knowledge but encourages interdisciplinary thinking, conceptual integration, and the effective use of technology. In the context of area calculation, this transformation can be observed through the integration of determinant matrices, definite integrals, and discriminants as complementary approaches for solving mathematical problems. The findings of this study reflect several important shifts in mathematics education that align with current developments in higher education.

Table 1. Higher Education Shift in Mathematics Learning

1 .From Single Method Learning to Multiple Method Learning
Traditional mathematics instruction often introduces only one standard method for solving area problems. This study demonstrates that area calculations can be approached through determinant matrices, definite integrals, and discriminants. Such diversity of approaches encourages students to understand mathematics from multiple perspectives and develop broader problem-solving competencies.
2. From Procedural Computation to Conceptual Understanding
Higher education increasingly emphasizes understanding mathematical concepts rather than merely performing calculations. The comparison of determinants, integrals, and discriminants enables students to understand the theoretical foundations behind each method and recognize the conditions under which each approach is most effective.
3.From Isolated Mathematical Topics to Interdisciplinary Integration.
The article integrates concepts from linear algebra, calculus, and analytic geometry within a

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single framework. This reflects a contemporary trend in higher education that promotes interdisciplinary learning and encourages students to identify relationships among different fields of knowledge.
4. From Formula Memorization to Analytical Reasoning Instead of relying solely on memorized formulas, students are encouraged to analyze problem characteristics before selecting a solution strategy. This shift strengthens critical thinking and supports the development of higher-order cognitive skills that are essential in modern mathematics education
5. From Fixed Problem-Solving Approaches to Flexible Method Selection The study shows that different mathematical methods possess distinct strengths and limitations. Students therefore need to evaluate computational efficiency, applicability, and problem characteristics before choosing an appropriate method. Such flexibility represents an important competency in contemporary higher education.
6.From Traditional Learning to Technology-Enhanced Learning The recommendation to incorporate visualization software and digital tools reflects the growing role of technology in mathematics education. Technology facilitates mathematical exploration, supports visualization of abstract concepts, and enables more interactive and learner-centered educational experiences.

SOCIAL LEARNING THEORY - ACADEMIC PERSPECTIVE

Social Learning Theory, developed by Albert Bandura, emphasizes that learning occurs through observation, imitation, interaction, and the sharing of experiences within a social environment. According to this perspective, knowledge is not acquired solely through direct instruction but is also developed through engagement with peers, educators, and broader communities of practice. Learners construct understanding by observing how others approach problems, interpret information, and apply knowledge in different contexts. Consequently, social interaction becomes a fundamental mechanism for cognitive development and skill acquisition.(Bandura 1986)

From an academic perspective, the article *Education on Building a Flat* reflects the principles of Social Learning Theory through its reliance on collective scholarly knowledge and the integration of previous research findings. The study synthesizes theories and methodologies from linear algebra, calculus, and analytic geometry while drawing upon textbooks, journal articles, and earlier mathematical studies to develop a comprehensive framework for area calculation. This

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process demonstrates how knowledge advances through academic interaction, where researchers learn from existing scholarship and contribute new insights to the wider educational community. Such collaborative knowledge construction represents a key characteristic of social learning in higher education(Schunk 2012).

Furthermore, the comparative analysis of determinant, integral, and discriminant methods encourages discussion, reflection, and the exchange of ideas among learners and educators. Students are not limited to observing a single solution strategy; instead, they are exposed to multiple approaches that can be evaluated and debated within academic settings. Through classroom interaction, collaborative problem-solving, and engagement with diverse mathematical perspectives, learners develop deeper conceptual understanding and stronger analytical skills. Therefore, Social Learning Theory provides a valuable framework for understanding how mathematical knowledge can be enhanced through academic collaboration, shared experiences, and collective inquiry.

CONNECTIVISM'S IMPLICATIONS FOR TEACHING AND LEARNING .

1. Institutional Support and Infrastructure. Educational institutions should provide adequate technological infrastructure, digital resources, and continuous evaluation systems to support network-based learning. Effective implementation of connectivism depends on access to technology and supportive learning environments.
2. The Role of Teachers and Facilitator Teachers remain essential as facilitators who guide learners in accessing, evaluating, and connecting information from various sources. Their readiness to adopt and utilize educational technology significantly influences learning effectiveness.
3. Learning Design and Digital Platforms Learning activities should be designed to encourage interaction, collaboration, and knowledge sharing through digital platforms. Well-structured online environments help students engage actively in constructing knowledge and solving problems.
4. Training and Practical Application Appropriate training for educators and students is necessary to maximize the benefits of connectivist learning. With adequate preparation, technology-enhanced learning can be effectively applied to improve understanding, collaboration, and problem-solving skills.

CONSTRUCTIVISM'S IMPLICATIONS FOR TEACHING AND LEARNING

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1. Teachers should stimulate students' interest and active participation by connecting learning activities with meaningful problems and real-world situations.
2. Students should be encouraged to explore multiple learning resources, including textbooks, research articles, digital media, and practical activities to construct their own understanding.
3. Instructors should identify students' existing knowledge and misconceptions before introducing new concepts to facilitate meaningful learning.
4. Learning environments should encourage discussion and knowledge exchange between students and instructors to deepen conceptual understanding.
5. Students should be empowered to share ideas, work collaboratively, and learn from the perspectives and experiences of others.
6. Teachers should provide learning experiences that challenge students' initial assumptions, encouraging them to reflect, revise, and reconstruct their understanding.(Piaget 1977)

DISCUSSION

The findings indicate that both matrix determinant and definite integral methods produce identical area values when applied to coordinate polygons bounded by linear functions. This consistency confirms the mathematical equivalence of the two approaches despite their different theoretical foundations. The determinant method originates from linear algebra and utilizes coordinate relationships among vertices, whereas the definite integral method is rooted in calculus and measures area through continuous accumulation. The equal results obtained for triangles, rectangles, parallelograms, kites, and trapezoids demonstrate that different mathematical representations can lead to the same geometric conclusion.

The comparative analysis further reveals that the determinant method is computationally more efficient for straight-sided polygons. The method requires only the coordinates of the vertices and can directly generate area values through determinant operations. In contrast, the definite integral method requires additional procedures, including determining boundary equations and identifying integration intervals before area calculations can be performed. Although this increases computational complexity, the integral approach offers greater flexibility because it can accommodate both linear and nonlinear boundaries. Therefore, the determinant method is more suitable for coordinate polygons, whereas definite integrals are more appropriate for regions bounded by curves.(Stewart 2016)

A similar pattern is observed in the comparison between discriminant and definite integral

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methods. For regions formed by the intersection of two quadratic functions, the discriminant approach provides a simpler computational procedure because it directly utilizes the coefficients of the quadratic equation. The results obtained in Cases I–V show that both approaches produce equivalent area values, confirming the validity of the discriminant method for specific quadratic cases. However, unlike the integral method, the discriminant approach cannot be generalized to higher-order polynomial functions or more complex nonlinear boundaries. Consequently, its application remains limited to particular geometric situations.(Antonides 2017)

From an educational perspective, these findings demonstrate the importance of introducing multiple solution strategies in mathematics learning. Students should not only learn how to perform calculations but also understand the strengths, limitations, and applicability of different mathematical methods.(Findell, Swafford, and Kilpatrick 2001) The integration of determinant, integral, and discriminant approaches encourages conceptual understanding, analytical thinking, and mathematical flexibility. Such an approach supports contemporary mathematics education, which emphasizes problem-solving competence and conceptual reasoning rather than procedural memorization alone.(Antonides 2017)

Furthermore, the study highlights the interconnected nature of linear algebra, calculus, and analytic geometry. Concepts that are often taught separately can be integrated to provide a more comprehensive understanding of area measurement. This interdisciplinary perspective may help students recognize relationships among mathematical topics and improve their ability to transfer knowledge across different contexts. Therefore, the incorporation of multiple approaches to area calculation has the potential to enrich mathematics instruction and contribute to the development of higher-order mathematical thinking skills.(Learn 2000)

CONCLUSION

Based on the theoretical analysis and comparative calculations conducted in this study, it can be concluded that the matrix determinant, definite integral, and discriminant methods are mathematically valid approaches for determining the area of plane regions within their respective domains of application. The results demonstrate that the determinant and definite integral methods produce identical area values when applied to linearly bounded polygons, while the discriminant and definite integral methods yield equivalent results for regions bounded by quadratic functions intersecting at two points. These findings confirm the consistency and accuracy of the mathematical principles underlying each method.

The study further reveals significant differences in efficiency among the approaches. The

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matrix determinant method is highly efficient for straight-sided polygons because it requires only the coordinates of the vertices and eliminates the need to derive boundary equations. Similarly, the discriminant method offers computational advantages for regions formed by the intersection of two quadratic functions, as it directly utilizes the parameters of the quadratic equation. In contrast, the definite integral method generally involves additional steps, including determining boundary functions and interval limits before area calculations can be performed.

Despite its greater computational complexity, the definite integral method possesses the highest level of flexibility. Unlike matrix determinants and discriminants, which are restricted to specific geometric conditions, definite integrals can be applied to a wide variety of linear and nonlinear boundaries, including curved regions that cannot be accommodated by standard determinant or discriminant formulas. Furthermore, the study highlights the distinct operational characteristics of these mathematical approaches: matrix determinants are grounded in discrete linear algebra with relatively constant computational procedures, whereas definite integrals are based on continuous calculus, where the complexity of calculations depends on the form of the boundary function. Therefore, the selection of an appropriate method should be based on the characteristics of the problem, the required computational efficiency, and the nature of the geometric region being analyzed

FUTURE DIRECTIONS

Future research is recommended to extend the comparison of matrix determinants, definite integrals, and discriminants to more complex geometric regions, including higher-order polynomial functions and irregular curved boundaries. The integration of mathematical visualization software and computational tools may also provide deeper insights into the efficiency, accuracy, and practical applications of these methods. Furthermore, future studies could investigate the effectiveness of incorporating multiple area-calculation approaches into mathematics education to enhance students' conceptual understanding, analytical thinking, and problem-solving skills.

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