

Indefinite integral automatic analysis mechanism research and development—Using integrals involving quadratic square roots as an example[☆]

Mu-Yu Ting^{a,*}, Bor-Chen Kuo^b

^a Center for General Education, National Formosa University, No. 64, Wunhua Rd., Huwei Township, Yunlin County 632, Taiwan

^b Graduate Institute of Educational Information and Measurement, National Taichung University of Education, No. 140, Minsheng Rd., West Dist., Taichung City 40306, Taiwan (R.O.C.)

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ABSTRACT

Using the capabilities of the knowledge structure theory, the researcher prepared a model for the experts' knowledge structure of the valid test items of the university Calculus topic "trigonometric substitution of indefinite integral about integrands involving quadratic square root". After the Calculus course was taught and tested, this knowledge structure model was combined with Bayesian network analysis to find the best recognition rate of Bayesian network and to identify easily the error types that students might make in learning "trigonometric substitution" unit. Then, the statistical information was analyzed using the Bayesian probability analysis methods to establish the "trigonometric substitution" unit model as an example of a Bayesian network adaptive diagnostic test system, to determine four established Bayesian network models to compare their recognition rates, and to establish this structure could be used as the foundation for developing remedial teaching approaches.

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1. Introduction

Unfortunately, "for the overwhelming majority of students, the calculus is not a body of knowledge, but a repertoire of imitative behavior patterns [1]". Although many calculus students are successful in performing procedural tasks in calculus, their understanding of underlying concepts is lacking [2,3]. Therefore, this study evaluated the use of the knowledge structure theory to determine the conceptual structure map of items, and then utilize Bayesian network analysis to develop the computerized diagnostic testing system of integrals, to propose four Bayesian network models to compare the recognition rates. to provide easy understanding of the students' learning situation to instantly detect student error types and, engage in subsequent remedial teaching.

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* Corresponding author.

Table 1
Calculus concepts, sub-concepts and content.

Concept	Sub-concept	Content
Limits and infinite series	Limit and continuous function	Sequences and Series, The Limit of Sequences and the sum of Infinite Series, The Limit of a Function, Continuous Function and its properties
Derivatives	The elementary concepts of Derivatives	Derivatives, Differentiation Rules, Higher-order derivatives, Derivatives of Trigonometric Functions, anti- trigonometric function, Derivatives of Exponential Functions and Logarithmic Functions, Derivatives of implicit functions, The Slope and Equation of the tangent line
	Applications of Differentiation	The Mean Value Theorem, The Shape of a Graph, Indeterminate Forms and L'Hospital's Rule, Antiderivatives
	Partial Derivatives	Functions of Several Variables, Partial Derivatives and its geometric meaning, The Chain Rule and partial derivatives of the implicit functions, Higher-order partial derivatives, Total differential, Extremes of Functions of two Variables
Integrals	The concept of Integrals	The Definite Integral, The Fundamental Theorem of Calculus, The properties and applications of Definite Integral
	Techniques of Integration	Integration by Substitution, Integration by Parts, Trigonometric Integrals, Trigonometric Substitution, Integration of Rational Function by Partial Fraction, Indefinite Integrals
	Applications of Integration	Areas Between Curves, Volumes, Arc Length, Area of a Surface of Revolution
	Multiple Integrals	Double Integrals, Iterated Integrals, Double Integrals in Polar Coordinates, Cylindrical and Spherical Coordinates, Triple Integrals, Applications of Triple Integrals

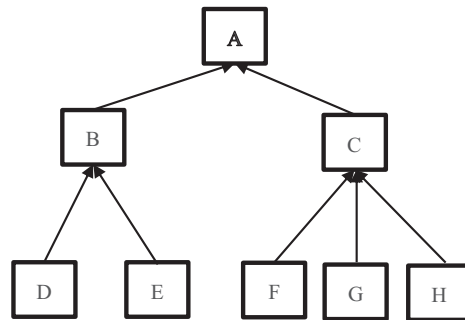


Fig. 1. The knowledge structure.

2. Materials and methods

2.1. Purposes

The purposes of this study are: (1) to use the experts' knowledge structure to determine the conceptual structure map of items, (2) to build an "indefinite integral" online test system, and (3) to diagnosis and analyze the effectiveness of indefinite integral's computerized responses.

2.2. Content quiz

However, Calculus is formed forms a bridge between basic mathematics and science.

Basic calculus including limits, derivative function, integral and infinite series constitutes the majority of modern university mathematics education. The concepts and the content of their respective sub-concepts are shown in Table 1:

2.3. The knowledge structure

As shown in Fig. 1, $B \rightarrow A$ denotes that item B was the prerequisite item of A. If a student answered correctly on item A, then the examinee would consider all of its prerequisite items (for example, item B ~ H) to be correct. If a student answered incorrectly on item A, then the examinee should take its prerequisite items (for example, item B or C) to understand where the student's real misconceptions are. If a student answered correctly on item B, then the system considered the items under item B (for example, item D and E) to all be mastered. If a student answered incorrectly on item B, then the student should take its prerequisite items (for example, item D or E).

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