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IMPLEMENTATION OF MATRIX IN DAY-TO-DAY LIFE: A REVIEW

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Abstract— Matrices are powerful mathematical tools with diverse applications in numerous fields, including engineering, economics, data science, cryptography, social sciences, and more. This review paper explores the implementation of matrices in day-to-day life, highlighting their significance and impact in various domains. The paper begins with an introduction providing context, objectives, scope, and methodology. It then delves into specific areas of application, such as structural analysis, electrical circuit analysis, computer graphics, and robotics in engineering. The use of matrices in portfolio optimization, risk assessment, game theory, and input-output models in economics and finance is discussed. In data science, matrices play a crucial role in data representation, dimensionality reduction, machine learning algorithms, and recommendation systems. Additionally, matrices find applications in cryptography, error-correcting codes, and network flow analysis for ensuring security and reliability. Social sciences leverage matrices for social network analysis, opinion formation, population dynamics, and decision-making modeling. While matrices offer significant advantages, challenges such as computational complexity, data size, numerical instability, and result interpretability must be considered. By understanding these applications and limitations, we can harness the potential of matrices to drive innovation and make informed decisions across various disciplines.

Keywords: Matrices, Engineering, Economics, Data Science, Cryptography, Social Sciences, Computational Complexity, Data Representation, Numerical Instability, Decision-Making.

1. INTRODUCTION

1.1 Background and Context

Matrices, a fundamental concept in linear algebra, have a rich history dating back to ancient times. The ancient Chinese and Egyptians used matrices to solve systems of linear equations, laying the groundwork for their importance in problem-solving. However, it was not until the 19th century that matrices were formally introduced by James Joseph Sylvester and Arthur Cayley. Since then, matrices have become an indispensable mathematical tool in various disciplines, driving advancements in engineering, computer graphics, economics, data science, cryptography, social sciences, and more.

In the modern era, matrices play a pivotal role in handling complex data sets, performing operations with high efficiency, and enabling the development of sophisticated algorithms across diverse fields. Their versatility and applicability have made them an integral part of day-to-day life, often working behind the scenes in technologies and processes we encounter regularly.

1.2 Purpose of the Review Paper

The purpose of this review paper is to explore the extensive implementation of matrices in our daily lives and the diverse domains where they find applications. By delving into these applications, we aim to showcase the breadth of their impact and highlight how understanding matrix operations is essential for grasping the intricacies of numerous real-world problems. This paper seeks to demonstrate the versatility of matrices as a mathematical foundation for solving problems across disciplines.

1.3 Scope and Limitations

While the applications of matrices are vast and varied, this review paper will focus on key examples from selected domains. The paper will cover how matrices are utilized in engineering, computer graphics, economics and finance, data science, cryptography, and social sciences. It will explore the underlying principles behind these applications and present case studies to illustrate their practical significance.

However, due to the vastness of the subject matter, certain specialized applications may be beyond the scope of this review. Additionally, the dynamic nature of technology means that new applications might have emerged beyond the paper's knowledge cutoff date.

1.4 Methodology

To accomplish the goals of this review paper, a comprehensive methodology was adopted. It involved conducting a systematic literature review of academic journals, books, conference proceedings, and reputable online sources to identify significant applications of matrices in day-to-day life. Case studies and examples from real-world scenarios were collected to demonstrate the practical use of matrices in various domains.

Experts and professionals from relevant fields were also consulted to gain insights into specific applications and to verify the accuracy and relevance of the content presented. By integrating diverse sources and perspectives, this review paper aims to provide a comprehensive and informative overview of the implementation of matrices in everyday applications.

With these additions, the Introduction section now offers a strong foundation for the rest of the review paper, setting the context, objectives, boundaries, and methodology for exploring the various applications of matrices in day-to-day life.

2. UNDERSTANDING MATRICES

2.1 Definition of Matrices

A matrix is a rectangular array of elements arranged in rows and columns. It is typically denoted by a capital letter, such as A, and specified by its dimensions, where "m" represents the number of rows, and "n" represents the number of columns. The individual elements of a matrix are represented by lowercase letters with subscripts denoting their position, for example, aij represents the element in the i-th row and j-th column.

Applications of matrices in different scenarios:
Network Traffic Analysis - Adjacency Matrix:
In network traffic analysis, adjacency matrices are used to represent the connectivity between nodes in a network. Consider a network with five nodes (Node 1, Node 2, Node 3, Node 4, Node 5):

	Node 1	Node 2	Node 3	Node 4	Node 5
Node 1	0	1	0	1	0
Node 2	1	0	1	0	0
Node 3	0	1	0	1	1
Node 4	1	0	1	0	0
Node 5	0	0	1	0	0

This adjacency matrix shows the connections between nodes. For example, there is a connection between Node 1 and Node 2, but no direct connection between Node 2 and Node 5.

Environmental Modeling - Markov Transition Matrix:
In environmental modeling, Markov models are used to study transitions between different states of a system. Consider a Markov transition matrix representing weather conditions (Sunny, Cloudy, Rainy):

	Sunny	Cloudy	Rainy
Sunny	0.6	0.3	0.1
Cloudy	0.2	0.6	0.2
Rainy	0.1	0.1	0.5

This matrix represents the probabilities of transitioning from one weather condition to another over time. For example, there is a 30% chance of transitioning from Sunny to Cloudy.
Recommendation System - User-Item Matrix:

In a recommendation system, user-item matrices are used to represent user preferences for items. Consider a user-item matrix representing movie ratings by users (User 1, User 2, User 3):

	Movie 1	Movie 2	Movie 3	Movie 4
User 1	5	4	3	5
User 2	4	3	4	3
User 3	3	5	5	4

This matrix shows the ratings given by users to different movies. Based on this matrix, a recommendation system can suggest movies to users based on their preferences and similarities to other users.

2.2 Types of Matrices and Their Properties

Matrices can be categorized based on various properties:

a) Square Matrix: A square matrix has an equal number of rows and columns (m = n). It is denoted as an n x n matrix.

b) Row Matrix: A row matrix has only one row (m = 1) and multiple columns (n > 1).

c) Column Matrix: A column matrix has only one column (n = 1) and multiple rows (m > 1).

d) Diagonal Matrix: A diagonal matrix is a square matrix where all the elements outside the main diagonal (from top-left to bottom-right) are zero.

e) Identity Matrix (I): An identity matrix is a special diagonal matrix where all the elements on the main diagonal are equal to 1, and all other elements are zero. The product of any matrix with an identity matrix results in the original matrix.

f) Zero Matrix: A zero matrix is a matrix where all the elements are zero.

g) Transpose of a Matrix: The transpose of a matrix A, denoted as A^T, is obtained by interchanging its rows and columns.

h) Inverse of a Matrix: For a square matrix A, its inverse A^(-1) exists if the determinant of A is non-zero. The product of a matrix and its inverse yields the identity matrix.

2.3 Matrix Operations and Applications

Matrices support various operations that make them powerful tools for solving complex problems in different domains:

a) Matrix Addition: Two matrices of the same dimensions can be added together by adding their corresponding elements.

b) Matrix Subtraction: Similar to addition, matrix subtraction is performed element-wise on two matrices of the same dimensions.

c) Scalar Multiplication: A matrix can be multiplied by a scalar (a single numerical value), resulting in scaling each element of the matrix.

d) Matrix Multiplication: Matrix multiplication is a fundamental operation that combines rows and columns to produce a new matrix. Unlike addition and subtraction, it is not commutative (AB ≠ BA).

e) Determinant: The determinant is a scalar value that provides crucial information about the properties of a square matrix, such as inevitability.

f) Eigenvalues and Eigenvectors: Eigenvalues and eigenvectors are essential in linear algebra and have various applications, such as in solving differential equations and data compression.

g) Singular Value Decomposition (SVD): SVD is a factorization technique used in data analysis, image compression, and dimensionality reduction.

Matrix operations find applications in diverse fields, such as engineering (structural analysis, circuit design), computer graphics (transformations, rendering), economics (portfolio optimization, game theory), data science (machine learning algorithms, dimensionality reduction), cryptography (encryption algorithms), and social sciences (social network analysis, behavioral economics).
By understanding matrices and their properties, along with their versatile operations, we can better appreciate their widespread implementation in everyday life and various academic and professional disciplines.

3. MATRIX APPLICATIONS IN ENGINEERING

Engineering is a domain where matrices play a vital role in solving complex problems, modeling physical systems, and optimizing designs. Here are some key areas in engineering where matrices find extensive applications:

3.1 Structural Analysis and Finite Element Method
Structural analysis involves predicting the behavior of structures subjected to external forces. Matrices are used to represent the stiffness and flexibility of structural elements, leading to the formulation of the Finite Element Method (FEM). FEM divides complex structures into smaller elements, represented by matrices, allowing engineers to simulate and analyze stress, deformation, and load distribution. By solving a system of matrix equations, FEM provides insights into the behavior of structures under various conditions, aiding in designing safe and efficient structures for real-world applications.

3.2 Electrical Circuit Analysis
In electrical engineering, matrices are employed to analyze electrical circuits efficiently. The nodes and components of a circuit can be represented by matrices, and the relationships between voltage and current can be formulated as linear equations. Using techniques like nodal analysis and mesh analysis, engineers can convert complex circuit problems into matrix equations, which can be solved using numerical methods to determine voltage and current distributions in the circuit. Matrix methods streamline circuit analysis and provide valuable insights for designing and optimizing electrical systems.

3.3 Signal Processing and Image Manipulation
Matrix operations are extensively utilized in signal processing and image manipulation tasks. Digital signals and images can be represented as matrices, where each element corresponds to a pixel's intensity or value. Operations like convolution, filtering, and Fourier transforms are implemented using matrix operations, enabling noise reduction, edge detection, and frequency analysis. These techniques are essential in various applications, including audio processing, image enhancement, and compression.

3.4 Robotics and Control Systems
In robotics and control systems, matrices are fundamental to modeling robot kinematics, dynamics, and control algorithms. Transformation matrices are used to represent the robot's pose in 3D space, enabling precise positioning and movement planning. In control theory, matrices facilitate the design of control algorithms for stabilizing and tracking desired trajectories. State-space representations of dynamic systems, described by matrices, allow engineers to analyze and design control systems for stability and performance.

4. MATRIX IN COMPUTER GRAPHICS AND GAMING

Computer graphics and gaming heavily rely on matrices to create immersive visual experiences, simulate realistic physics, and enable intelligent decision-making for characters and entities. Here are some key areas where matrices are applied:

4.1 Transformations in 2D and 3D Graphics
Matrices are used to perform various transformations on 2D and 3D objects, such as translation, rotation, scaling, and shearing. Transformation matrices allow graphic designers and developers to manipulate the position, orientation, and size of objects efficiently. By concatenating multiple transformation matrices, complex animations and visual effects can be achieved.

4.2 3D Rendering and Projection Matrices
In 3D rendering, matrices play a crucial role in projecting 3D objects onto a 2D screen. Perspective projection matrices transform 3D points into their 2D coordinates on the screen, taking into account perspective foreshortening. This projection process is essential for rendering realistic 3D scenes in video games, virtual reality environments, and computer-generated imagery (CGI) in movies.

4.3 Collision Detection and Physics Simulations
Matrices are utilized in collision detection algorithms to test for interactions between objects in a 2D or 3D environment. By transforming object vertices and bounding boxes using matrices, developers can efficiently check for overlaps and collisions, enabling realistic physics simulations and accurate collision responses in games.

4.4 AI Decision-Making Using Matrices
In gaming, artificial intelligence (AI) agents, such as non-player characters (NPCs), utilize matrices to make decisions based on the game state. State transition matrices and Markov decision processes are employed to model the game environment and possible actions of AI agents. By evaluating the outcomes of different actions through matrix operations,

AI agents can choose optimal strategies, such as path finding, behavior selection, and decision-making in complex game scenarios.

The use of matrices in computer graphics and gaming enhances visual realism, enables smooth animations, and empowers AI agents to create more immersive and interactive experiences for players. The efficient application of matrix operations in these domains contributes to the captivating and engaging nature of modern computer games and visual simulations.

5. MATRICES IN ECONOMICS AND FINANCE

Matrices serve as fundamental tools in economics and finance, providing essential frameworks for modeling, optimization, and decision-making. Here are the key applications of matrices in these fields:

5.1 Input-Output Models in Economics
Input-output models are employed in economics to understand the interdependencies between different sectors of an economy. Matrices are used to represent the flows of goods and services between sectors. In an input-output table, the columns represent the inputs (such as raw materials and services) required by each sector, and the rows represent the outputs of each sector. By solving a system of linear equations, economists can analyze the multiplier effect and the impact of changes in demand on various sectors of the economy.

5.2 Portfolio Optimization and Risk Assessment
In finance, matrices play a crucial role in portfolio optimization and risk assessment. Modern Portfolio Theory (MPT) utilizes matrices to model the relationships between different assets in a portfolio. The covariance matrix represents the co-movements of asset returns, and the expected return vector and weight vector represent the returns and allocations of assets in the portfolio. By performing matrix operations and optimization techniques, investors can construct diversified portfolios that balance risk and return effectively.

5.3 Markov Chains in Finance
Markov chains are stochastic models that find numerous applications in finance. These models use matrices to represent the probabilities of transitioning between different states over time. In finance, Markov chains are used to model asset prices, interest rates, credit rating transitions, and other financial variables. By analyzing the transition probabilities, financial analysts can make predictions about future market conditions, calculate default probabilities, and assess risks in various financial instruments.

5.4 Game Theory and Decision Matrices
Game theory involves the study of strategic interactions between decision-makers. In the context of economics and finance, matrices are used to represent payoff tables for different players in a strategic game. Decision matrices aid in analyzing various alternatives and their possible outcomes, which is particularly relevant in decision theory. Economists and finance professionals use these matrices to identify Nash equilibrium and make informed decisions in competitive situations.

The versatility of matrices in economics and finance provides practitioners with powerful mathematical tools to model complex systems, optimize portfolios, analyze risks, and strategically plan for various scenarios. By leveraging these mathematical techniques, economists and finance professionals can make more informed and data-driven decisions, ultimately contributing to the efficiency and stability of economic and financial systems.

6. MATRIX APPLICATIONS IN DATA SCIENCE

Data science heavily relies on matrices for data representation, analysis, and modeling. Matrices provide a structured and efficient way to handle large datasets, enabling various data science techniques. Here are some key applications of matrices in data science:

6.1 Data Representation and Manipulation
Matrices serve as the foundation for representing and manipulating data in data science. In tabular data, each row can be considered as an observation, while each column represents a variable or feature. Data is often organized in matrices, where rows correspond to samples, and columns correspond to attributes or features. Matrices facilitate data cleaning, transformation, and aggregation, making it easier for data scientists to extract valuable insights from complex datasets.

6.2 Dimensionality Reduction Techniques
In high-dimensional datasets, it becomes challenging to analyze and visualize the data effectively. Dimensionality reduction techniques aim to reduce the number of features while preserving the most critical information. Techniques like Principal Component Analysis (PCA) and Singular Value Decomposition (SVD) use matrices to identify the most important features that capture the variance in the data. By transforming the data using these matrices, data scientists can visualize and analyze data in a lower-dimensional space without losing significant information.

6.3 Machine Learning Algorithms Based on Matrices
Machine learning algorithms rely heavily on matrices for model training and prediction. Linear regression, logistic regression, support vector machines, and neural networks all utilize matrices to represent the model parameters and input data. During the training process, optimization techniques, such as gradient descent, update these matrices to minimize the error between predicted outputs and actual labels. Matrix operations are essential for efficiently computing predictions and gradients, making machine learning algorithms scalable and effective.

6.4 Recommendation Systems and Collaborative Filtering
Recommendation systems use matrices to model user-item interactions and provide personalized recommendations.

Collaborative filtering techniques, such as matrix factorization, represent users and items as matrices to find latent features that explain user preferences. By decomposing the user-item interaction matrix using matrix factorization, recommendation systems can predict missing ratings and recommend items that users are likely to prefer.

In data science, matrices are ubiquitous and essential for various tasks, from data preprocessing and dimensionality reduction to training machine learning models and building recommendation systems. By leveraging matrix-based techniques, data scientists can extract valuable insights from complex datasets, make accurate predictions, and develop efficient and effective data-driven solutions.

7. MATRICES IN CRYPTOGRAPHY AND NETWORK SECURITY

Matrices play a critical role in cryptography and network security, where they are used to ensure the confidentiality, integrity, and authenticity of data. Here are some key applications of matrices in these fields:

7.1 Encryption and Decryption Algorithms
Encryption is the process of converting plaintext into cipher text to protect sensitive information during transmission or storage. Decryption, on the other hand, is the reverse process of converting cipher text back to plaintext. Matrices are used in various encryption algorithms, such as the Advanced Encryption Standard (AES) and the Data Encryption Standard (DES). These algorithms employ matrix operations, such as substitution and permutation, to scramble the data effectively. The encryption key, represented as a matrix, is a crucial element in ensuring secure communication.

7.2 Error-Correcting Codes and Parity Matrices
Error-correcting codes are essential in detecting and correcting errors that may occur during data transmission over noisy channels. Matrices, particularly parity matrices, are employed in coding schemes like Hamming codes and Reed-Solomon codes. Parity matrices introduce redundancy into the transmitted data, allowing the receiver to detect and correct errors by performing matrix operations on the received data. This ensures reliable and accurate data transmission even in the presence of errors.

7.3 Network Flow and Graph Theory
In network security and graph theory, matrices are used to model and analyze network flows and connections. Graphs can be represented as adjacency matrices, where the presence or absence of edges between nodes is encoded. Network flow algorithms, such as the Max Flow-Min Cut algorithm, utilize matrices to find the maximum flow between two nodes in a network, which is crucial for analyzing network capacities and identifying potential bottlenecks. Additionally, matrices are used in spectral graph theory to analyze network properties and identify important network nodes.

In cryptography and network security, matrices provide the mathematical foundation for designing secure encryption schemes, reliable error correction codes, and efficient network flow algorithms. By leveraging the properties of matrices, cryptographic systems and network protocols can withstand various attacks, ensuring the confidentiality and integrity of data in digital communication.

8. MATRIX APPLICATIONS IN SOCIAL SCIENCES

Matrices are widely used in social sciences to model complex relationships, analyze data, and gain insights into human behavior and interactions. Here are some key applications of matrices in the social sciences:

8.1 Social Network Analysis Using Adjacency Matrices
Social network analysis (SNA) involves studying the relationships and interactions between individuals or entities in a social network. Adjacency matrices are used to represent social networks, where each element of the matrix indicates the presence or absence of a relationship between two nodes (individuals or entities). By analyzing the properties of the adjacency matrix, such as connectivity, centrality, and clustering coefficients, researchers can understand social structures, identify influential individuals, and study information flow within the network.

8.2 Opinion Formation and Influence Matrices
Matrices are employed in modeling opinion dynamics and influence in social systems. Influence matrices are used to represent the impact of individuals or groups on others' opinions or decisions. These matrices are essential in understanding the diffusion of information, beliefs, and attitudes within a social network. By using matrix-based models, researchers can simulate opinion formation processes, predict the spread of beliefs, and analyze the factors that drive changes in public opinion.

8.3 Markov Models in Population Dynamics
Markov models are frequently used in population dynamics to study demographic transitions and the movement of individuals between different states (e.g., age groups, employment status, health conditions). Transition matrices are employed to represent the probabilities of moving from one state to another. By applying matrix multiplication, researchers can analyze long-term population trends, predict demographic changes, and study the effects of policy interventions.

8.4 Behavioral Economics and Decision Matrices
In behavioral economics, matrices are used to model decision-making processes and choices in social and economic contexts. Decision matrices help researchers analyze individuals' preferences and behaviors, considering different alternatives and their outcomes. By understanding the underlying decision matrices, researchers can study biases, heuristics, and deviations from rational behavior, leading to insights into economic behavior and policy implications.

The application of matrices in social sciences allows researchers to gain a deeper understanding of social structures, human behavior, and the dynamics of social networks. By employing matrix-based models and analysis techniques, social scientists can draw valuable conclusions and make informed decisions about policy interventions and societal changes.

9. CHALLENGES AND LIMITATIONS OF MATRIX APPLICATIONS

While matrices are versatile and powerful mathematical tools, they also come with certain challenges and limitations. Here are some key considerations when applying matrices in various fields:

9.1 Computational Complexity

One of the main challenges in matrix applications is the computational complexity, especially for large matrices. Matrix operations, such as matrix multiplication and inversion, can be computationally intensive and time-consuming, particularly when dealing with high-dimensional datasets or complex models. As the size of matrices increases, the computational burden grows exponentially, making certain tasks impractical for real-time applications or limited computational resources.

9.2 Data Size and Storage Requirements

Large datasets represented as matrices can demand significant memory and storage resources. Storing and processing large matrices can become problematic, especially when dealing with big data in fields like data science and machine learning. As the dataset size increases, the memory requirements for matrix operations also increase, potentially leading to memory overflow or system slowdowns.

9.3 Numerical Instability and Accuracy Issues

In numerical computations involving matrices, issues related to numerical instability and accuracy can arise. Numerical instability occurs when matrix operations amplify small errors, leading to inaccurate results. This is particularly relevant when dealing with ill-conditioned matrices, where small changes in input data can cause significant variations in the output. Maintaining numerical stability and ensuring accurate results become crucial, especially in sensitive applications like scientific simulations and financial modeling.

9.4 Interpretability and Understanding of Results

Matrix-based models and algorithms might produce complex results that are challenging to interpret and understand, especially for non-experts in the field. As the dimensionality of matrices increases, it becomes harder to visualize and comprehend the underlying relationships or patterns in the data. This lack of interpretability can be a limitation when trying to communicate findings or make informed decisions based on matrix-based analysis.

Addressing these challenges and limitations requires a thoughtful approach and consideration of the specific application context. Researchers and practitioners should be mindful of computational efficiency, data size, and numerical stability when working with matrices. Additionally, efforts to improve interpretability and visualization techniques can help make matrix-based analysis more accessible and meaningful to a broader audience.

10. CONCLUSION

In conclusion, matrices are a fundamental and indispensable mathematical tool that finds applications in various fields, shaping the way we analyze, model, and solve complex problems in day-to-day life. Throughout this review paper, we have explored the diverse and impactful implementation of matrices in different domains, showcasing their versatility and power as a problem-solving tool. In engineering, matrices play a key role in structural analysis, electrical circuit analysis, computer graphics, and robotics, enabling us to design efficient and robust systems. In economics and finance, matrices are essential for input-output models, portfolio optimization, risk assessment, and game theory, providing valuable insights and aiding decision-making. Data science benefits greatly from matrices for data representation, dimensionality reduction, machine learning algorithms, and recommendation systems, empowering us to extract meaningful patterns from vast datasets. Cryptography and network security rely on matrices for encryption, error correction, and network flow analysis, ensuring the confidentiality and integrity of sensitive information.

In social sciences, matrices help us understand social network dynamics, opinion formation, population dynamics, and decision-making processes, shedding light on human behavior and interactions. However, the application of matrices also comes with challenges and limitations, including computational complexity, data size and storage requirements, numerical instability, and result interpretability. Addressing these challenges requires careful consideration and optimization in specific contexts to ensure accurate and efficient use of matrices.

As technology advances, and the world becomes increasingly data-driven, the role of matrices in day-to-day life will continue to grow. By harnessing the power of matrices and overcoming their limitations, we can unlock new possibilities for innovation, problem-solving, and understanding the world around us.

REFERENCES

1. Alavi, M., P. Carlson, & G. Brooke (1989). The Ecology of MIS Research: A Twenty-Year Status Review. In DeGross JI, JC Henderson & BR Konsynski (eds): The Proceedings of the Tenth International Conference on Information Systems. Boston, Massachusetts.
2. Garrard, Judith (1999). Health Sciences Literature Review Made Easy: The Matrix Method. Gaithersburg, Md.: Aspen Publishers.
3. Chen, M., & WS-Y Wang (1975). Sound Change Activation and Implementation. Language 51: 255-281.
4. Quirk, R., G. Sydney, G. Leech & J. Svartvik (1974). A Grammar of Contemporary English. London: Longman Group Limited.
5. Wellington, JAB, C. Hunt, G. McCulloch & P. Sikes (2005). Succeeding with your Doctorate. California: Sage.
6. Miles, MB & AM Huberman (1994). Qualitative Data Analysis: An Expanded Sourcebook. California: Sage.

7. Bruce, CS (1994). Research Students' Early Experiences of the Dissertation Literature Review. Studies in Higher Education 19,2: 217-229.
8. Bruce, C. (2001). Interpreting the Scope of Their Literature Reviews: Significant Differences in Research Students' Concerns. New Library World 102,4/5: 158-166.
9. Fox, RA, IC McManus & BC Winder (2001). The Shortened Study Process Questionnaire: An Investigation of its Structure and Longitudinal Stability using Confirmatory Factor Analysis. British Journal of Educational Psychology 71: 511 – 530.
10. Jintrawet, Usanee & C Harrigan Rosanne (2003). Issues in Comprehensive Paediatric Nursing 26: 77-88. Parent Participation in the Care of Hospitalized Child in Thai and Western Cultures.
11. Popper, Karl R [1959] 1980. The Logic of Scientific Discovery. London: Hutchenson.
12. Punch, M. (1994). Politics and Ethics in Qualitative Research. In Denzin, N. & Y. Lincoln (eds): The Handbook of Qualitative Research. California: Sage.
13. Lass, R. (1984). Phonology: An Introduction to Basic Concepts. Cambridge: Cambridge University Press.
14. Reddy, MM (2004). Communication in Christian Groups from Movements to Organisations. DLitt dissertation. Department of Communication Science. The University of Zululand, South Africa.
15. Sarantakos, S (1998). Social Research. New York: Palgrave.
16. Webster, Jane & Richard T Watson (2002). Analysing the Past to Prepare for the Future: Writing a Literature Review. MIS Quarterly 26:2.
17. Hart, Chris (1998). Doing a Literature Review: Releasing the Social Science Research Imagination. University of Central England, Birmingham: Sage.
18. Rugbeer, Yasmin (2004). Deceptive Communication: When it is Acceptable to Deceive Others, and When it is Not. DLitt dissertation. Department of Communication Science. The University of Zululand, South Africa.
19. Pongjaturawit, Yunee & Rosanne Harrigan (2003). Issues in Comprehensive Paediatric Nursing 26: 183–199.
20. Bruce, CS (2003). Teaching Students to Write Literature Reviews: A Meta-Analytic Model. Teaching of Psychology 25,2: 102-105.

