GOAL SETTING AND EXECUTIVE FUNCTION USING MATRIX GRAPHIC ORGANIZERS[1]

Russell Jay Hendel
Department of Mathematics
Room 316, 7800 York Road
Towson Maryland, 21252
RHendel@Towson.Edu

ABSTRACT

The paper first reviews the pedagogic usefulness of the matrix graphic organizer. This usefulness is well established in the literature. The paper then shows how the matrix graphic organizer meets the pedagogic excellence criteria of executive function, goal-setting, and several educational hierarchies. This paper also points to the need to use a unified approach to pedagogy and assessment. Illustrative examples are provided using the topics *quadratic equation* and *solving simultaneous linear systems.*

Keywords: matrix graphic organizer, quadratic equation, linear algebra, simultaneous systems, pedagogic excellence, pedagogic hierarchy, executive function, goal setting

1. GRAPHIC ORGANIZERS

1.1 Paper Goal: The purpose of this paper is to show how skillful use of tables, matrix graphic organizers, can be used to enhance pedagogy by meeting the pedagogic criteria of excellence of executive function and challenging goal-setting.

This section briefly defines, reviews, and explains the advantages of graphic organizers for pedagogy.

1.2 **Definition of Graphic Organizer**: Margaret Egan [9] gives the following brief but comprehensive description of graphic organizers: “A graphic organizer is a visual representation of knowledge, a way of structuring information, and of arranging essential aspects of an idea or topic into a pattern using labels.” Flood and Lapp [10] use the term "mapping" generally to describe any illustrative material that helps children learn from texts. These materials could include charts, graphs, maps, flowcharts, or other structures that help one visualize the materials in texts. Essentially, the terms graphic organizer and mapping are used interchangeably to describe a similar instructional activity.”

Graphic organizers were introduced by Ausibel [3,4,5].

1.3 Enhancement of Pedagogy: Graphic organizers are widely used. Their enhancement of pedagogy on all levels of learning and for all types of learners, including challenged learners, is well documented [1, 8, 11, 14, 30, 31, 32].

There have been literally hundreds of studies on advanced organizers. Consequently, several meta-studies have been performed such as those by Kozlow [19] who reviewed 77 studies and Luiten, Ames and Ackerson [23] who reviewed 135 advanced organizer studies using Glass' meta-analysis technique. Based on these studies they conclude that advance organizers increase both learning and retention, with learning effects increasing rather than declining over time. Although graphic organizers are also effective with (mentally and socially) challenged learners they are most effective with high ability individuals

Graphic organizers are less beneficial if all that an instructor wants is knowledge of facts. They are most beneficial when they accompany a poorly written source text. Graphic organizers are best for relational learning [13, 18, 34].

1.4 Matrices (Tables): Matrices (tables) are one of the many forms of graphic organizers. The two-dimensional matrix format enables students to discover (a) hierarchical relations, (b) coordinate relations, and facilitates students (c) applying that knowledge in new situations. Contrastive learning is one sign of advanced pedagogy [33].

The visual organizational design of matrices comes closer to meeting Tukey's [36, p. 375] standards for effective visual displays: “The greatest possibilities of visual display lie in vividness and inescapability of the intended message. A visual display can stop your mental flow in its tracks, and make you think. A visual display can force you to notice what you never expected to see. One should see the intended at once; one should not even have to wait for it to appear.”

The rest of this paper deals with matrix graphic organizers. It is very likely that the results of this paper generally apply to all graphic organizers.

2. AN ILLUSTRATIVE EXAMPLE

2.1 Source: Robinson and Kiera [33] give a charming example precisely showing how the format of a matrix, independent of content, facilitates learning. However, this example uses a specialized field, schizophrenia. This paper therefore adapts the example to the more intuitive tiling patterns. This paper also uses their example to respond to a limitation in graphic organizers pointed out by Marzano.

[1] Acknowledgement to Professor Michael Krach of Towson University for a careful proofreading of the manuscript.

2.1 Outline Approach: The illustrative example presented in this section deals with four tilings called A, B, C, and D. The tilings differ in shading (light or dark), texture (plain or grid) and border (thin or thick). Following Robinson and Kiera this paper first presents an outline approach, presented below, summarizing the information.

Robinson and Kiera point out that:

- In-tilling attributes are easy to learn: For example, it is easy for a student to learn, using this outline, that Tile B, is dark-shaded, with a grid texture, and single borders
- Cross-tilling attributes are harder to learn: For example, after students learn this outline, they may not notice that Tile B is the only tile with a grid texture.

Tiling Outline

A:

Shade:	Light
Texture:	Solid
Border:	Single

B:

Shade:	Dark
Texture:	Grid
Border:	Single

C:

Shade:	Dark
Texture:	Solid
Border:	Thick

D:

Shade:	Dark
Texture:	Solid
Border:	Solid

2.2 Matrix Approach: The matrix graphic organizer corresponding to the tilling outline is presented in Table 1:

Tiling	A	B	C	D
Shade of Grey	Light	Dark	Dark	Dark
Texture	Solid	Grid	Solid	Solid
Border	Single Line	Single Line	Thick	Thick

Table 1: Matrix of the four tilings and their attributes

As Robinson and Kiera point out: The coordinate relationships for each attribute and for each tile is very clearly communicated. From the matrix, it is easy to see that Tile B is the only tile with a grid texture while from the outline it is not as easy to see. Other attribute patterns, for example, that Tile A is the only light tile or that Tiles C and D are thick-bordered tiles, are also apparent from the matrix organizer.

A key point made by Robinson and Kiera is that:

- The outline and matrix contain *identical* information
- They differ in *format* and readability. The matrix format allows more relationships to be seen; in particular, it allows one to see that commonalities and differences in both the tilings as well as their attributes.

Thus, this simple example with two organizers containing identical information, clearly illustrates the pedagogic value of graphic organizers (in this case matrices).

2.3 Marzano's Cautions: Robert Marzano has written extensively on what works best in teaching, in assessment, and in classroom management [25, 27, 28]. His research is supported by numerous studies.

Marzano [26] however cautions against the "trend" to simply always apply the approaches that research has declared as working well. He points out that 20%-40% of the time the research that generally works well may not however work well in a particular situation.

This paper argues that the existing literature, can, and in fact does, answer this caution, in the specific case of matrices. The literature for example already points out that for learning facts, matrix organizers are not superior. Matrix organizers are precisely good for cross-item comparisons.

But then the solution to *how* matrices should be used so as to maximize and increase pedagogy are clear. The instructor must

- Teach the material
- Present the matrix
- Show how patterns can be inferred in rows and columns
- Explain to students that assessment (a.k.a. as tests) will have questions on both items and attributes (row and column) patterns.

By explaining and requiring that the matrix organizer will be used for what it is good for, the instructor is guaranteed increased student performance.

On a historical note, this pairing of instruction and assessment is already mentioned by Robinson and Kiera [33]: they point out that the lack of study time available to students or lack of appropriate spacing can erase the beneficial effects of matrices.

3. PEDAGOGICAL EXCELLENCE

3.1 The Hierarchies: The idea of pedagogical hierarchies was introduced by Bloom [7] in the last half of the last century. At a very simple intuitive level, Bloom posited that an activity like memorization, is low-level, while an activity like analysis is high-level.

Following Bloom, several other researchers, including Gagne [12], Van-Hiele [37], Anderson [2], and Marzano [24], put forth their own hierarchies.

Recently, it has been shown that some of these hierarchies are equivalent in the precise sense that similar pedagogic improvement will occur if either of them is used [15].

3.2 The Four Pillars: Hendel [15] made three contributions:

1) He proposed a unification of the theories. That is, he presented deep underlying psychological concepts which all hierarchies possess.
2) He explicitly connected the proposed unification with the psychological processes connected with higher level thinking such as executive function.

3) Hendel's four pillars are operationally defined. They are very easy to test for. They do not use vague terms like analysis, synthesis, or challenge. For example, higher level thinking is a consequence of using *multiple* areas of the mind.

Hendel [15] posits that superior education is based on four pillars:

I. Executive Function: This refers to simultaneously using two or more parts of the brain, for example, teaching multi-step problems, multi-component problems, or problems involving formal, computational, verbal and visual aspects (the *rule of four* [17]).

II. Goal-Setting: Goal-setting refers to breaking up a complex task into subtasks. Goal setting is superior if subgoals are i) specific and clear, ii) challenging, and iii) achievable timely [21, 22].

III. Attribution theory: The instructor-student relationship should foster an atmosphere where the student attributes success to internal controllable activities such as effort and work versus luck [38].

IV. Self-efficacy: The single most important determinant of pedagogic success is self-efficacy, the student's belief that with his or her present skills, knowledge, and abilities he or she can accomplish certain challenging tasks [6].

Of these four pillars

- Pillars I and II deal with content
- Pillar III deals with the instructor-student relationship
- Pillar IV deals with the student self-perception.

The bullets below illustrate how Pillars I and II, particularly Pillar I, unifies the hierarchies:

- *Matching* intrinsically involves two parts of the brain (one part for each list you are matching) Therefore *matching,* an analysis activity in the Marzano hierarchy, fulfills executive function criteria.
- *Classification* intrinsically involves two parts of the brain (one part for the parent categories and one part for the children categories). Therefore, *classification*, an analysis activity in the Marzano hierarchy, fulfills executive function.
- Memorizing a list (like the alphabet, or the list of states) does not involve multiple brain areas and therefore is a pedagogically low level activity in both the Bloom, Anderson, and Marzano hierarchies.

4. APPLICATION OF THE 4 PILLARS TO MATRICES

Sections 1-2 presented literature and rationale for why matrix organizers are *superior* pedagogically. But Hendel posits that *superior* pedagogy is completely described by the four pedagogic pillars. Therefore, the purpose of this section is to demonstrate that use of matrices fulfills the requirements of the four pedagogic pillars. This demonstration provides deeper insight into which properties of matrices lead to their superior pedagogy. Proper goal setting will also provide insights and tips for classroom use.

4.1 Executive Function: The relationship between matrices and executive function should be obvious. Matrices communicate content and are arranged in a specific visual layout. Therefore, understanding matrices requires use of two parts of the mind, the part of the mind understanding content and the part processing the visual. By engaging two parts of the mind, executive function is used, leading to superior pedagogy.

4.2 Goal Setting: The relationship between matrices and goal-setting is not obvious. We recommend the following goal setting (using the tile example from earlier sections).

- First teach about the items, the columns, which in this case are tiles
- Then teach about the attributes (the rows)
- Then present the matrix and illustrate how it can be used to uncover patterns whether in the tile items or attributes

The above procedure fulfills requirements of proper goal-setting:

- Is clear and specific
- Is timely achievable (four tiles and three attributes)
- Is challenging since the student will still struggle to uncover patterns (We point out that Table 1 is only a 3 x 4 matrix. Typical learning situations may have 10 x 15 matrices. Learning all patterns "for the test" is very challenging but nevertheless specific, clear, and timely achievable and enhances, not detracts, from the syllabus).

4.3 Attribution Theory: As indicated in Section 2, instructors, besides teaching using matrices must also assess using matrices. The attribution pillar can explain this.

A student who learns using matrices but is not tested on row and column patterns sees success as dependent on external non-controllable items. After all, had she or he not studied using the matrices and the test only had patterns visible on an outline he or she would have succeeded. Thus, success does not depend on study methods and work; it also depends on how the instructor assesses.

By both teaching and assessing using matrices (that is, assessing on patterns in items and attributes (columns and rows) one fulfills attribution-theory requirements: Success is dependent on an internal controllable activity: By applying the matrix organizer approach, the student can learn everything they need to.

4.4 Self-efficacy: As explained by Hendel [15], use of graphic organizers leads to improved self-efficacy through the following cycle of events:

- Instructor presentation of the graphic organizer method
- Student practice of the method
- Student mastery of the method due to practice
- Reduced student anxiety due to mastery of the method
- Increased practice due to reduced anxiety
- Increased self-efficacy due to increased practice

This last bullet reflects the fact that performance is the strongest driver of self-efficacy [15]. As noted in [6, 15] self-efficacy is the single most important predictor of student success and student satisfaction.

5. SIMPLE ILLUSTRATION

To illustrate the use of graphic organizers, the quadratic equation, a topic from 7-12 mathematics, is used. This section will be self-contained. Some standard references are [20, 29].

5.1 Illustrative Examples: Quite simply a quadratic equation is an equation in a variable say X with a square term X^2. To give the flavor of the attributes of interest, some simple examples are listed below.

1. $X^2 = 4$ has two solutions, X=2, X=-2
2. $X^2 = -1$ has no real solutions but has two imaginary (complex) solutions. In fact, the imaginary number, i, and its complement -i, the square roots of -1, are both solutions
3. $0= X^2- 3X+2 = (X-1)(X-2)$ has two solutions X=1, and X=2
4. Although $X^2 = 0$ has one solution X=0, it has two solutions counting multiplicity (The equation $X^2=0$ is perceived as $(X-0)(X-0)=0$ implying that it has two solutions, one for each factor)

5.2 A, B, C, D: The general quadratic equation can be perceived as having the form $AX^2+BX+C=0$, with A, B, C integers, real numbers, or complex numbers. Illustrations in this paper use integer A, B, C. It is convenient to define a fourth number the discriminant, $D = B^2 - 4AC$.

Table 2 presents the calculation of A, B, C, and D for the four examples.

Equation	A	B	C	D
$X^2 = 4$	1	0	-4	16
$X^2 = -1$	1	0	1	-4
$0= X^2- 3X+2$	1	-3	2	1
$X^2 = 0$	1	0	0	0

Table 2: Values of A, B, C, D for four quadratic equations

5.3 The Quadratic Root Theory: Using a matrix graphic organizer, Table 3 compactly presents the traditional quadratic theory about roots. The attributes governing the roots of quadratic equations, presented in Section 5.1, are:

- Number
- Multiplicity
- Type (integer, complex)
- Descriptive language

Importantly, this list of attributes includes both mathematical and verbal concepts: This is consistent with the Executive-Function principle. The matrix is presented in Table 3.

Value of D	Number of Roots	Number Type	Is multiplicity present	Descriptive language
D>0	2	Real	No	2 roots
D<0	0	Real	No	No real roots
	2	Complex	No	2 complex roots
D = 0	1	0	Yes	1 root with multiplicity 2
	2	0	Yes	2 roots counting multiplicity

Table 3: Number and type of roots depending on value of D

5.4 Applications of the Matrix: Several points can be made about the matrix presented in Table 3 relative to traditional textbook pedagogic method.

Notice how the matrix gives equal weight, a separate row, to items that are special and rare. For example, two rows are given to discussion of the D=0 case. There are two non-mathematical verbal ways of describing this case. On the one hand, in current textbooks and teaching, a great deal of time is devoted to doing computational examples such as for example for the D > 0 case; on the other hand, although, it is desirable for students to know equally about the D = 0 case including its verbal descriptions, equal time to this case (as for example measured by the proportions of exercises found in many textbooks on these four cases) is not always provided. Contrastively, the matrix organizer presents a row for each case, providing equal weight.

The preceding observations reinforce the point, made several times in this article, that superior pedagogy requires a unified approach of assessment and pedagogy. If a concept (such as multiplicity) is important, then instructional materials and assessment preparatory materials should expose the students to it with appropriate weight. This is not always done.

It should be obvious how to use the matrix presented in Table 3 to teach important, especially rare, concepts.

This section only covered the theory of quadratic roots. Quadratic equations have many other interesting properties such as extrema, vertices, and convexity type. There are also many applications of quadratic equations only some of which are presented in textbooks [16].

6. SIMULTANEOUS SYSTEMS OF LINEAR EQUATIONS

This section applies the matrix graphic organizer method to linear algebra [35]. Linear algebra is a rich subject with many applications. However, as with the quadratic equation, this paper suffices with exclusive focus on solving systems of equations. As pointed out in Section 5, emphasis is given that certain rare topics are not always emphasized equally, a problem remedied by matrix graphic organizers. The matrix organizers also allow illustration of the method of goal setting presented in Section 4.2.

6.1 Types of Solutions: There are three cases, although in practice, textbooks emphasize those with unique solutions:

- A system like X+Y=5 and X-Y =1 has one solution X=3, Y=2.
- A system like X+Y+1=2 and X+Y+2 = 2 has no solutions
- A system like X-2A-3B=4 has a 2-parameter set of infinite solutions X=4+2A+3B where A and B are arbitrary integers

The matrix organizer for the types of solution to systems of equations is presented in Table 4.

Number solutions	Example	Solutions if applicable	Comments
1	X + Y=5 X – Y=1	X=3, Y=2	
0	X+Y+1=2 X+Y+2 =2	NA	
Infinite	X-2A-3B=4	X=4+2A+3B	2 parameter solution space

Table 4: Matrix organizer for types of solutions

6.2 Issues in Solving Equations: As one goes about solving equations there are certain high-level goals that present themselves. The following illustrates these goals:

- For an equation set like 2X=4 and 3Y=9, the goal would be to have the coefficients of X and Y, 1, so that the solution can be seen immediately
- For an equation set like X=2 and 2X+3Y=13 the goal would be to eliminate the 2X term (that is find an equivalent equation with 0X instead of 2X)

- Finally, depending on the number of equations, one might have a goal to rearrange the equations so that the equation matrix has a traditional triangular type appearance with solutions of earlier listed variables appearing first.

These three goals are normally stated in the context of matrix goals and are called the Gauss-Jordan elimination method; this form uses three row rules, row echelon form, and reduced row echelon form. However, the numerical matrix methods are simply a convenience. The entire theory can be comfortably developed with the familiar variables, as will be done in this section. This approach makes students, use to variable representations of equations, but not use to abstract numerical matrices, more comfortable.

The matrix graphic organizer for goals is presented in Table 5

Goal	Example	Effect of Goal
Coefficient 1	2X= 4, 3Y=9	Increased readability
Coefficient 0	X=2; 2X+3Y=13	Eliminate variables solved so as to solve others
Rearrange equations	Applies to complex systems	Readability

Table 5: High-Level Goals for Solving Equations

6.3 Equation Rules: Corresponding to each high-level goal, there are equation rules to achieve these goals (in the matrix theory, these are known as row rules). Illustration is provided using the examples presented in Section 6.2:

- If 2X=4 then both sides can be divided by 2 to obtain X=2 Similarly both sides of 3Y=9 by 3 can be divided by 3, to obtain Y=2. This is called the division equation (row) rule.
- If X=2 and 2X+3Y=13 then twice the first equation can be subtracted from the second equation to eliminate the 2X term: [2X+3Y=13] – 2 [X=2] = [0X+3Y=9] = [3Y=9]. This operation will be called the subtraction-equation operation. It is used when one equation has a coefficient of 1 for X and it is desired to eliminate (make 0) the coefficients of X in the other equations. (Of course, in this particular example, it is "easier" to simply plug in X=2 into the second equation, rather than row reduce, however, it is easy to construct more sophisticated examples where the row reduction is a more transparent approach).
- Rearranging equations is an obviously needed operation and goal: The variables should be arranged in some known sequential order (for example, x, y, z (alphabetical) or x_1,x_2, x_3 (numerical)) so the value of any particular variable can be accessed quickly.

Table 6 summarizes the matrix graphic organizer associated with the three equation rules.

6.4 Properties of Terminal Equation Sets: How does one know when the equation set looks right? That the solution has been arrived at? And that it is not necessary to perform any other equation rules? In other words, how is the *terminal* goal of the problem recognized. Here are some easy examples of desirable properties:

- An equation set of the form 0X+0Y=1, 0X+0Y=1 clearly is in final form (0=1). It was reduced to an absurdity and therefore there are no solutions (This is not always emphasized in textbooks)
- An equation set of the form of X=1, Y=2 clearly is in final form since the solution can be read off immediately. Notice how each equation has one variable, that variable has a coefficient of 1, and that variable does not occur in any other equation.
- Similarly, an equation set of the form X-2A=1, Y-3B=2 is in final form since in this case X=1+2A, Y=2+3B with A and B parameters. This form is recognized by noting that i) each variable has a coefficient of 1 in one equation and does not occur in any other equation, however, there may be parameters in the equation indicating an infinite solution.

Rule name	Illustrative equation set	Row operation	Comments
Division	2X=4 3Y=9	½ * [2X=4] = [X=2] 1/3 * [3Y = 9] = [Y=3]	Used to make coefficients 1; simply divide both sides by coefficients of variables
Subtraction	X=2 2X+3Y=13	[2X+3Y=13] - 2[X=2] = [3Y=9]	Used when i) one equation has a coefficient of 1 and ii) other equations have nonzero coefficients. You subtract that coefficient multiplied by the equation with a 1 coefficient
Rearrangement	Complex equation sets	Obvious operation of rearrangement	

Table 6: The three equation (row) rules

Table 7 presents the matrix graphic organizer for terminal solutions.

6.5 Discussion: Tables 4-7 present all issues in solving systems of equations (This paper deviates in minor ways from the traditional row-rule approach with numerical matrices since the goal presented in this paper is to teach students, not program computers; but the above approach is completely comprehensive and rigorous)

The tables and their discussions show how concepts should be introduced (goal setting). Actual class settings would require more examples and more time spent. This paper emphasizes that the proper treatment of linear algebra should cover all cases (illustrative problems and practice exercises should equally address no-solution equations and multi-parameter infinite solutions). The tables provide greater clarity and summarize all issues without omitting any information. The enhancement of pedagogy by this matrix graphic organizer approach can be combined with other pedagogical approaches including emphasis on applications and hands-on projects.

Terminal Form property	Number of Solutions	Solution to the system of equations
No variable has a non-zero coefficient	0	No solutions
Each variable has exactly one equation with a 1 coefficient and has 0 coefficients in all other equations	1 Solution to complete set of equations	If there are no parameters, the solution can be seen immediately; e.g. X= some number, Y equals some number, …
There are a set of variables with each variable in the set having one equation with a 1 coefficient and 0 coefficients in all other equations. There may still be extra variables left (parameters)	An infinite number of solutions parameterized by possibly several parameters.	The solution can be obtained by solving. For example, if X-2A=1 and Y-2B=3 then X has exactly one equation with a 1 coefficient and 0-coefficients in all other equations (same for Y). The solution is X=1+2A, Y=3+2B

Table 7: Possible Terminal Properties of equation sets

7. CONCLUSION

This paper has explored a well-known pedagogic aid, the matrix graphic organizer. The paper has emphasized:

- Executive function properties of matrices
- How to use matrices to achieve challenging goal setting
- How to use matrices to emphasize rare-textbook items.

These methods apply to any subject. For reasons of space, the very beautiful literature on using matrices for (mentally, physically, and socially) challenged students was not covered. Research shows that these methods do help these students [11].

Instructors are encouraged to begin incorporating these methods as supplements to other instructional, high-yielding strategies that they currently use.

8. REFERENCES

[1] D. Alvermann, “Graphic organizers: Cueing devices for comprehending and remembering main ideas,” In J.F. Baumann (Ed.), **Teaching main idea comprehension** (pp. 210-226). Newark, DE: International Reading Association. 1986.

[2] L. W. Anderson, D. R. Krathwohl and B. S. Bloom, **A Taxonomy for Learning, Teaching and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives**: Complete Edition, NY: Longman, 2001.

[3] D. Ausibel. “The use of advance organizers in the learning and retention of meaningful verbal material,” **Journal of Educational Psychology**, 51,1960, pp. 2-272.

[4] D. Ausibel. **Educational Psychology: A Cognitive view**, NY: Holt, Rinehart and Winston Inc. 1968

[5] D. Ausibel, “In defense of advance organizers: A reply to the critics,” **Review of Educational Research**, 48, 1978, pp 251-257.

[6] A. Bandura, **Self-efficacy: The Exercise of Control**, New York, NY: W. H. Freeman, 1997.

[7] B. Bloom, Taxonomy of Educational Objectives: **The Classification of Educational Goals**, NY: Longman,1956.'

[8] K. Bromley, K., L. Irwin-DeVitis, and M. Modlo, **Graphic organizers: Visual activities for active learning.** New York: Scholastic Professional Books, 1995.

[9] Margaret Egan, “Reflections on Effective Use of Graphic Organizers,” **Journal of Adolescent & Adult Literacy**, 42(8), May 1999, pp. 641-645.

[10] J. Flood, & D. Lapp, “Conceptual mapping strategies for understanding information texts,” **The Reading Teacher**, 41, 1988, pp. 780-783.

[11] M. Friend & W. Bursuck. **Including students with special needs: A practical guide for classroom teachers**. Boston: Allyn & Bacon, 1999.

[12] R. M. Gagne, **The Conditions of Learning**, N.Y., NY: Holt, Rinehart and Winston, 1965.

[13] S. Guri-Rosenblit, “Effects of a tree diagram on students' comprehension of main ideas in an expository text with multiple themes,” **Reading Research Quarterly**, 24, 1989, pp. 236-247.

[14] J. E. Heimlich and S. D. Pittelman. **Semantic mapping: Classroom applications**. Newark, DE: International Reading Association, 1986.

[15] R. J. Hendel, "Leadership for Improving Student Success through Higher Cognitive Instruction", in Ronald Styron and Jennifer Styron, Editors, **Comprehensive Problem-Solving and Skill Development for Next-Generation Leaders**, Hershey, PA: IGI Publishing, 2017.

[16] Russell Jay Hendel, “Are we meeting pedagogic requirements?- The quadratic equation, “**Journal of Systemics, Cybernetics, and Informatics**, 16(1), 2018, pp. 12-19.

[17] D. Hughes-Hallett et al, **Calculus: Single and Multivariable** (6th ed.), Hoboken, NJ: Wiley, 2012.

[18] K.A. Kiewra & R. A. Sperling. How supplemental representations affect learning from a research article. Paper presented at the **Annual meeting of the American Educational Research Association**, Chicago, 1991

[19] M. Kozlow. **A Meta-analysis of selected advannce organizer research reports from 1960-1977**, Columbus Ohio: Ohio State University, 1978 (ERICDB 161755)

[20] R. Larson, R. Hostetler, and D. Falvo, **Algebra and Trigonometry (6th ed.)**, Boston: Houghton Mifflin, 2004.

[21] E. Locke, K. Shaw, L. Sari, and G. Latham, “Goal-setting and task performance: 1969-1980.” **Psychological Bulletin**, Vol. 90, No. 1, 1981, pp. 125-152.

[22] E. A. Locke and G. P. Latham, **A Theory of Goal Setting and Task Performance**, Englewood Cliffs, NJ: Prentice Hall, 1990.

[23] J. Luiten, W. Ames, and G. Ackerson. “A meta-analysis of the effects of advance organizers on learning and retention,” **American Educational Research Journal**, 17(2), 1980, pp. 211-218.

[24] R. Marzano, **Designing a New Taxonomy of Educational Objectives**, Thousand Oaks, CA: Corwin Press, 2001.

[25] Robert J Marzano, **Classroom management that works: facilitator's guide**, Alexandria, Va.: Association for Supervision and Curriculum Development, 2004.

[26] Robert Marzano, "Setting the Record Straight on high-yield strategies," **Phi Delta Kappan**, 91(01), 2009, pp. 30-37

[27] Robert J Marzano and Ceri B. Dean, **Classroom instruction that works: research-based strategies for increasing student achievement**, Boston, Mass.: Pearson Education, 2013

[28] Robert J Marzano, **Making classroom assessments reliable & valid**, Bloomington, IN: Solution Tree Press, 2018
[29] Jerald Murdock, Ellen Kamischke, and Eric Kamischke. **Discovering Algebra: An Investigative Approach** (2nd Edition), Emeryville, CA: Key Curriculum Press, 2007.
[30] J. Murray & C. McGlone, "Topic overview and the processing of topic structure." **Journal of Educational Psychology**, 89(2), 1997, pp. 251-261.
[31] P. D. Pearson, & R. Spiro. "The new buzz word: Schema," **Instructor**, 91(9), 46-48, 1982
[32] D. Reutzel & P. C. Fawson, P.C. "Using a literature webbing strategy lesson with predictable books," **The Reading Teacher**, 43, 208-215, 1989.
[33] Daniel H. Robinson & Kenneth A. Kiewra. "Visual Argument: Graphic Organizers Are Superior to Outlines in Improving Learning from Text," **Journal of Educational Psychology**, 87(3), 1995, pp. 455-467.
[34] D. H. Robinson & G. Schraw. "Computational efficiency through visual argument: Do graphic organizers communicate relations in text too effectively?" **Contemporary Educational Psychology**, 19, 1994, pp. 399-415.
[35] Gilbert Strang**, Introduction to Linear Algebra,** 5th edition, Wellesley, MA: Wellesley-Cambridge Press 2016
[36] J. W. Tukey. Data-based graphics: Visual display in the decades to come. In **Proceedings of the meeting of the American Statistical Association: Invited Paper Sessions** (pp. 366-381). Washington, DC: American Statistical Association. Wainer, 1990
[37] P. van Hiele, Structure and Insight: **A Theory of Mathematics Education,** Orlando: Academic Press, 1986.
[38] B. Weiner, "An Attributional Theory of Achievement, Motivation, and Emotion", **Psychological Review**, Vol. 92, No. 4, 1985, pp. 548-573.