AC 2011-238: ASSESSMENT BASED ON THE PRINCIPLES OF HOWARD GARDNER'S THEORY

Mysore Narayanan, Miami University

DR. MYSORE NARAYANAN obtained his Ph.D. from the University of Liverpool, England in the area of Electrical and Electronic Engineering. He joined Miami University in 1980 and teaches a wide variety of electrical, electronic and mechanical engineering courses. He has been invited to contribute articles to several encyclopedias and has published and presented dozens of papers at local, regional , national and international conferences. He has also designed, developed, organized and chaired several conferences for Miami University and conference sessions for a variety of organizations. He is a senior member of IEEE and is a member of ASME, SIAM, ASEE and AGU. He is actively involved in CELT activities and regularly participates and presents at the Lilly Conference. He has been the recipient of several Faculty Learning Community awards. He is also very active in assessment activities and has presented dozens of papers at various Assessment Institutes. His posters in the areas of Bloom's Taxonomy and Socratic Inquisition have received widespread acclaim from several scholars in the area of Cognitive Science and Educational Methodologies. He has received the Assessment of Critical Thinking Award twice and is currently working towards incorporating writing assignments that enhance students' critical thinking capabilities.

Assessment Based on Howard Gardner's Theory of Multiple Intelligences

Mysore Narayanan, Miami University, Ohio.

Abstract

Scholars in the area of cognitive science and educational psychology agree that *'assessment'* as *'learning'* should not be treated like a third-party research project or some administrator's questionnaire. Assessment must be actually viewed as a community effort or nothing. Assessment must be driven by a faculty's own commitment to reflect, react, innovate and improve. Educators have also recognized that it is very important that instructors make a strong effort to teach to the sensory strengths of the learners. Harvard University Professor Howard Earl Gardner suggested that the *Intelligence Quotient,* alone should not become the primary basis for measuring human potential. In order to accommodate the diverse learning styles of the present-day students, one should effectively utilize modern techniques and implement technology intelligently as a valuable instructional tool. Renowned educator Walter Barbe indicates that the degree of processing speed, accuracy and retention that an individual is able to accomplish when encountering information depends upon to what extent the medium in which information presented matches his or her learning style. Award winning psychologist Anthony Grasha was also of the opinion that it was important to acknowledge the fact that students do indeed learn better when alternative modes of information processing are made available at college campuses. The author has taken the input from these all these scholars and has experimented on implementing some of their ideas into his classroom activities. The author believes that the creative adaptation of these ideas provides an instructor with quantitative results based on a solid foundation of cognitive psychology. The actual assessment of these classroom activities may ultimately have the potential to arm the instructor with valuable insight pertaining to the learning styles of the twenty first century student. In this presentation, the author provides an analysis of the data he has collected and compares them with the data of other scholars like Howard Gardner and Hunter Boylan.

Introduction

Howard Gardner defined intelligence as *'the capacity to solve problems or to fashion products that are valued in one or more cultural setting.'* It is important to recognize the fact that all children do not learn the same way. Learners rely on different sensory modes to help them learn. Some depend heavily on their sense of sight, whereas some others may prefer to rely on their sense of hearing. Still, some others may depend on their sense of touch to obtain a good understanding. Gardner proposed that there are seven broad areas wherein children and adults can excel and listed them as follows (Gardner & Hatch, 1989).

1. Word Smart: Linguistic Intelligence
2. Number Smart: Mathematical Intelligence
3. Picture Smart: Visual Intelligence
4. Body Smart: Kinesthetic Intelligence
5. Music Smart: Musical Intelligence
6. People Smart: Interpersonal Intelligence
7. Self Smart: Intrapersonal Intelligence

All schools, colleges and universities appreciate the need, importance and impact of linguistic and mathematical intelligences at almost every stage of a learner's educational career. Reading, writing and a working knowledge with numbers are considered as essential foundation for establishing a strong base of general knowledge. However, the next three, namely, visual, kinesthetic and musical intelligences are normally associated with the disciplines of fine arts and performing arts. Finally, the last two were defined as *'personal intelligences'* by Howard Gardner. There is also a possibility of adding two or three more to the above mentioned list. The need for including *naturalist intelligence* and *existential intelligence* has been mentioned (Gardner, 2000).

Gardner's work has been marked by a desire not to just describe the world but to help to create the conditions to change it. The scale of Howard Gardner's contribution can be gauged from following comments in his introduction to the tenth anniversary edition of his classic work:

Frames of Mind. The theory of multiple intelligences:

In the heyday of the psychometric and behaviorist eras, it was generally believed that intelligence was a single entity that was inherited; and that human beings - initially a blank slate - could be trained to learn anything, provided that it was presented in an appropriate way. Nowadays an increasing number of researchers believe precisely the opposite; that there exists a multitude of intelligences, quite independent of each other; that each intelligence has its own strengths and constraints; that the mind is far from unencumbered at birth; and that it is unexpectedly difficult to teach things that go against early 'naive' theories of that challenge the natural lines of force within an intelligence and its matching domains. (Gardner 1993: xxiii)

Howard Gardner has been recognized as a paradigm shifter. This is because Gardner questioned the idea that intelligence is a single entity, that it results from a single factor, and that it can be measured simply via IQ tests. Howard Gardner's work around multiple intelligences has had a profound impact on thinking and practice in education. Gardner also challenged the cognitive development work of swiss psychologist, Jean Piaget. Gardner brought forward evidence to show that at any one time a child may be at two very different stages of development (Armstrong, 1994). Howard Gardner's theory of multiple intelligences has been embraced by a range of educational theorists and, significantly, applied by teachers and policymakers to the problems of schooling.

Marchese's Research

Theodore Marchese, Senior Consultant at *Academic Search,* served 18 years as vice president of the American Association for Higher Education (AAHE) and was a *Senior Lecturer* at the Harvard Graduate School of Education. Marchese indicates that Assessment is a process in which rich, usable, credible *feedback* from an act of teaching or curriculum comes to be *reflected* upon by an academic community, and then is *acted* on by that community, a department or college, within its commitment to get smarter and better at what it does (Marchese, 1997, page 93). Innovative instructors, like *reflective practitioners* in other professions, constantly test, adjust, and reframe their models of practice on the basis of experience and feedback. Marchese is also of the opinion that *important knowledge cannot be abstracted from the situations in which it is learned and used. One must acknowledge that knowledge is ever a part of a particular activity, context, and culture.* So far, scientists have not presented researchers with a coherent set of ideas about how the brain works that would be persuasive and usable for educators and instructors. All of which is to say, assessment is more than data gathering (Marchese 1991). It also encompasses essential functions of meaning-making, action, and commitment to improve. All of this is by way of introducing an exercise Marchese conducted with university faculty sometime ago that attempted to capture a *wisdom of practice* out of the *powerful pedagogies* that have sprung up on campus in recent years.

All educators are aware of these powerful pedagogies and most of them have a very strong following. A short list is given below. (http://www.newhorizons.org/lifelong/higher_ed/marchese.htm)

1. Collaborative Learning
2. Cooperative Learning
3. Multicultural Learning
4. Problem Based Learning
5. Portfolio Based Learning
6. Experiential Learning
7. Case Method Learning
8. Peer Based Learning
9. Journal Based Learning
10. Research Based Learning
11. Leadership Based Learning
12. Capstone Course Based Learning

Marchese indicates that virtually all of the above mentioned approaches have been fashioned by classroom teachers as a response to real problems with real students (Marchese 1997). These were not made up by researchers.

So, if one were to ask a question:

What are the common assumptions these pedagogies make about learning?

The answers are:

The more a teacher can emphasize . . .

- learner independence and choice
- intrinsic motivators and natural curiosity
- rich, timely, usable feedback coupled with occasions for reflection and
- active involvement in real-world tasks
- emphasizing higher-order abilities
- done with other people in high-challenge, low-threat environments
- that provide for practice and reinforcement

. . . the greater the chances he or she will realize the deep learning that makes a difference in student lives.

The author has utilized several of these principles outlined by Theodore Marchese while teaching engineering subjects at Miami University. He has also applied some of Ted Marchese's ideas into his classroom activities. As a result of this activity the author was able to collect and analyze several sets of data. These results have been previously presented and published at the National Conference of the American Society for Engineering Education in Austin, Texas (Narayanan, 2009).

Learning Atmosphere

It has been a well established fact that learning is an interactive process that takes place in educational environment established specifically to promote to enhance knowledge in a *learning atmosphere* (Keefe, 1987). Researchers have actually demonstrated that if one utilizes technology systematically, it actually helps the instructor address perceptual dimensions of learning (Keefe, 1991). It is also important that technology should not be viewed just as a growing trend. It must be intelligently implemented as an invaluable instructional tool that can accommodate diverse learning styles of 21st century students (Watkins, 2005).

Dr. Walter B. Barbe is a nationally known authority in the fields of reading and learning disabilities. Barbe has shown that perceptual modality styles provides an indication of an individual's dominant learning mode (Barbe & Milone, 1980). The degree of processing speed, accuracy and retention that an individual is able to accomplish when encountering information depends upon to what extent the medium in which information presented matches his or her learning style. Furthermore, it is also important to acknowledge that students learn better when alternative modes of information processing are made available at college campuses (Gardner, 2000). In other words, problems related to learning most frequently are not related to the complexity of the subject matter. It may actually relate to the level of cognitive process that is absolutely essential to master the material at the required level (Keefe, 1988).

Anthony F. Gregorc of the University of Connecticut at Storrs and Helen B. Ward of Northbrook, Illinois are of the opinion that educators must be able to successfully address the needs of the individual by relating their own teaching style to the learning style of the individual. In other words, instructors should have a clear understanding of what the word *individual* means (Gregorc and Ward, 1977). The four learning styles identified by the Gregoric Style Delineator - *concrete sequential, abstract random, abstract sequential, and concrete random* have been discussed in detail by several researchers and this has been recorded in Appendix H.

Anthony Gregorc also contends that strong correlations do indeed exist between the individual's disposition, the media, and teaching strategies:

> *Individuals with clear-cut dispositions toward concrete and sequential reality chose approaches such as ditto sheets, workbooks, computer-assisted instruction, and kits. Individuals with strong abstract and random dispositions opted for television, movies, and group discussion. Individuals with dominant abstract and sequential leanings preferred lectures, audio tapes, and extensive reading assignments. Those with concrete and random dispositions were drawn to independent study, games, and simulations. Individuals who demonstrated strength in multiple dispositions selected multiple forms of media and classroom approaches. It must be noted, however, that despite strong preferences, most individuals in the sample indicated a desire for a variety of approaches in order to avoid boredom.* ((Gregorc, 1984, p. 54)

Modality Strength Characteristics

The concept of modality and modality-based instruction is not at all new. Italian physician educator, Maria Montessori and noted literacy instruction educational psychologist Grace Fernald began practicing modality-based instruction decades ago. (Fernald, 1921 & 1943). So did French Physician Jean-Marc Gaspard Itard when he worked with *Wild Boy Aveyron.* A difference between these early approaches and contemporary practice is that today's modality-based instruction can be applied to every classroom. Furthermore, we now have several means of assessing a child's modality strengths. A short list may include for example:

1. Swassing-Barbe Checklist of Observable Modality Strength Characteristics (Barbe & Swassing, 1979).

2. The Illinois test of psycholinguistic abilities by Kirk, McCarthy & Kirk (Kirk & Kirk, 1967).

3. The Dunn and Dunn Learning Style Model of Instruction from UCLA (Dunn & Dunn, 1979 & 1987).

4. Barbe and Milone Modality Index (Barbe & Milone, 1980).

Instructional strategies that effectively include variety in vocabulary has been discussed by many writers (Borasi, 1998; Carbo and Hodges, 1988; Gardner, 1993). Some of these and other researchers contend that literature coupled with teacher-student talk adds value to vocabulary (Penno, 2002). Carbo and Hodges also state that *"matching learning styles of students with appropriate instructional strategies improves their ability to concentrate and learn."* If mismatching occurs, students feel anxious and even physically ill when trying to learn. American psychologist and psychometrician Robert Jeffrey Sternberg says: *"Most teachers are best at teaching children who match their own styles of thinking and learning."* (Sternberg, 1994, p. 39). Sternberg also reports that students tend to receive higher grades when their styles are the same as those of their teachers. Assuming that this is true, one would conclude that teachers must learn to be flexible and exhibit different styles in their classroom.

Lewis R. Aiken of Pepperdine University has served as a consultant for numerous educational, governmental, health, and industrial organizations and has worked in many different educational and research establishments. Aiken's *Questionnaires & Inventories: Surveying Opinions and Assessing Personality* offers innovative for scholars and researchers alike. Aiken's popular textbook *Psychological Testing & Assessment* remains a best-seller in its field, having recently entered a tenth edition. The author has taken several ideas from Aiken's textbooks and has adapted them to help the students develop intellectual curiosity while they learn the engineering subject matter (Aiken, 1997, 2000).

Hunter R. Boylan is the Chairperson for American Council of Developmental Education Associations. In his book, *What Works: Research-Based Best Practices in Developmental Education*, Dr. Boylan gives tips for accommodating diversity through instruction. His tips are to train faculty in alternative forms of instruction if they are expected to use diverse instructional methods. One must administer a learning styles inventory to the students as a regular assessment process, and then share the learning styles information with the faculty to encourage faculty to accommodate dominate learning styles and that students learn best when they have a visual representation and can manipulate objects associated with the concepts (Boylan, 1997 & 2004).

Neil D. Fleming of Lincoln University, New Zealand has taught in a wide variety of educational establishments. As a scholar with an international perspective, his writing can be found in key faculty development journals in Britain, North America, and Australia and New Zealand. Fleming is best known for the development and introduction of the *VARK* questionnaire. This methodology is designed to provide students with a profile of their learning preferences, and alert the instructor to the variety of approaches to learning through a process of discovery. *VARK* system of organization suggested four important categories that seemed to identify students' learning behavior. *VARK* is an acronym that stands for Visual, Auditory, Read (includes writing), and Kinesthetic sensory modalities that humans employ for learning and processing information (Fleming and Mills ,1992).

The author believes it is important to recognize all these researchers who have generously contributed in the area of cognitive science, educational psychology and educational methodologies.

Implementation and Assessment

Seven characteristic intelligences identified by Howard Gardner were studied by the author while he taught the subject matter of engineering statics. The data collected has been tabulated using an excel spreadsheet and a bar graph was generated to facilitate analysis. A detailed discussion of the results has been recorded in Appendix A.

A matrix was generated to document grading and analysis. A sample of this table is shown in Appendix B. The data obtained was based on *Likert Scale* and was tabulated and recorded using an excel spreadsheet. Several *"Primary Traits"* or *"Characteristics"* were identified and assessed. The complete analysis of the bar chart generated is detailed in Appendix C.

The author has also experimented on utilizing the principles of Fleming and Mills' *VARK* questionnaire in a different form in his classroom activities. As a result of this activity, the author was able to collect and analyze a set of data. These results have also been presented here, in Appendix C. Furthermore, the author's data has also been compared with the data of Hunter Boylan in Appendix D.

The procedure followed by the author while conducting this study is shown in Appendix E. The data collected was analyzed using *Washington State University's Critical Thinking Rubric.* This rubric has helped the instructor effectively address and assess multiple intelligences and multiple dimensions of learning. The rubric has been reproduced in Appendix F. Likert scale bar chart and analysis is shown in Appendix G.

It must be emphasized that the author effectively uses modern technology while teaching at Miami University. He has utilized World Wide Web and Interactive Video Distance Learning extensively in addition to other teaching techniques. *W.W.W.* and *I.V.D.L.* actually supplement other routinely used audio visual techniques such as power point presentations, tutorials, problem-solving sessions, written research reports, peer group discussions, poster presentations etc.

The author utilizes a variety of instructional tools to communicate with students who may prefer to have different learning styles (Kolb, 1985). The author also recommends and encourages students to utilize the resources that are readily available at the university, such as *Library, Writing Center, Computer Laboratory,* etc.

Furthermore, working with this Washington state university rubric has provided the author the necessary guidance for moving in the *appropriate direction.* Here, one must stress the importance of identifying the ultimate goal. The ultimate goal,

however, is to deliver the needed information to students in the best possible manner that suits the *receiver's optimum learning style.*

Conclusions

Generation of a well designed bar chart provides the instructor help with visual data analysis. Important strengths and weaknesses can be easily identified using the bar chart.

Referring to the bar graph shown in Appendix A:

One observes that maximum possible Likert Scale score of **5** has been accomplished in the *Body Smart* category identified by Howard Gardner. This indicates that the students do learn best by performing experiments in a laboratory setting. In other words, the learners have the ability to effectively correlate their theoretical background knowledge to solving actual real-world problems.

Both the categories: *Picture Smart* and *People Smart* have recorded a Likert Scale score of **4** indicating that students do *understand* best when they actually *see* it. Furthermore, a respectable score of **4** in the category of *People Smart* implies that the students' team work has been successful. Students are capable of understanding better when one utilizes the principles of *engaging with other learners.*

The *Number Smart* category records an average score of **3** which is not an acceptable score for engineering students. Engineers need to be really very proficient in rigorous mathematical analysis and calculations. Improvement in this category is essential and one should make efforts to raise this to the maximum possible value of **5.**

A *Likert Scale Score* of **2** has been recorded for both the *Self Smart* and *Word Number Smart* categories. This shows that that the students are not yet ready to learn on their own. The subject matter of *Statics* is perhaps one of the very first of a group of engineering courses the students are experiencing. As such they are still in the *learning* mode of applying laws of physics and rules of mathematics to engineering models. An unacceptable score of **2** in the *Word Smart* cateogory indicates the inability of students express to their thoughts using writing as a tool. Students need to become effective communicators and their written communication skills must be improved to record at least **4** preferably **5.**

The author has also experimented on using Fleming and Mills' *VARK* questionnaire in his classroom activities. It is very interesting to observe that the data collected using *VARK* principles are in excellent agreement with those acquired using the principles of Howard Gardner.

These results, based on the *VARK* principles have been presented here, in Appendix F. Referring to the bar graph shown in Appendix F:

It can be seen that an excellent mode value of **5** was recorded for *Kinesthetic* style of learning. This is in excellent agreement with Likert Scale score of **5** that was accomplished in the *Body Smart* category identified by Howard Gardner.

Reading style recorded a low score of **2.** Again, this is in excellent agreement with the *Likert Scale Score* of **2** that was recorded for *Word Smart* category identified by Howard Gardner.

Finally, the *Visual* category recorded an acceptable value of **4.** This again, is in excellent agreement with the data collected during the previous experiment. The *Picture Smart* category recorded a Likert Scale score of **4** indicating that students do *understand* best when they actually *see* it.

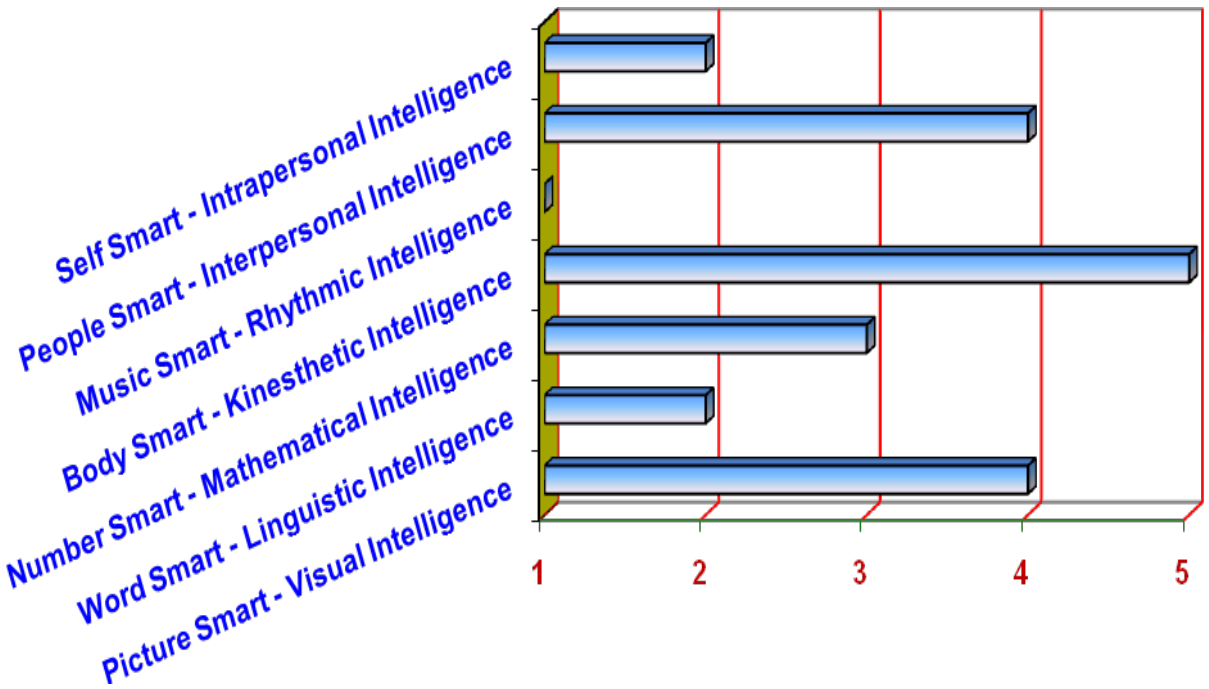
The author has also drawn from Hunter Boylan's research and has tried to compare his data with those of Boylan. This comparison chart is shown in Appendix G. It is very important to recognize that the author's data is significantly different from those of Hunter Boylan's research. The author acknowledges that his engineering discipline is completely different from that of Dr. Hunter Boylan.

Furthermore it should be recognized that each topic or subject matter may be different and the difference may be huge and significant. Each instructor's delivery style is different and one may even arrive at two different sets of data for the same subject and topic when two different instructors are involved The author agrees and understands that these data may *vary significantly* depending upon subject matter, instructor's delivery styles, material content, discipline, student body, etc. It is possible that *Visual* and *Kinesthetic* modes of learning may be preferred by students engineering disciplines. Such assessment data provides the instructor to make appropriate changes in the manner in which the course is developed and may necessitate changes in *Instructional Delivery Styles* (Narayanan, 2007).

Acknowledgements

Dr. Mysore Narayanan is extremely grateful to the Center for the Enhancement of Learning and Teaching and Committee for the Enhancement of Learning and Teaching for granting him the award: *Faculty Learning Community to Accentuate Performance in Student-Centered Learning.* Dr. Narayanan also thanks Dr. Milt Cox, Director of Center for the Enhancement of Learning and Teaching at Miami University for his valuable suggestions and guidance. The author is extremely grateful to Dr. Gregg W. Wentzell, Managing Editor for the *Journal on Excellence in College Teaching* for his invaluable input. The author also thanks Dr. Paul Anderson, Director, *Roger and Joyce Howe Center for Writing Excellence* for his valuable guidance and encouragement.

APPENDIX A: Assessment Based on Howard Gardner's Theory of Multiple Intelligences (Summary for 58 students)



Analysis of the Bar Chart. [Likert Scale. 5: Strongly Agree 1: Strongly Disagree]

Self Smart: An unacceptable score of **2** indicates that the students are still in the *learning* mode of applying laws of physics and rules of mathematics to engineering models.

People Smart: A respectable score of **4** in the category of *People Smart* implies that the students' team work has been successful. Students are capable of understanding better when one utilizes the principles of *engaging with other learners.*

Music Smart: This was not studied in this engineering course.

Body Smart: The maximum possible Likert Scale score of **5** has been accomplished in this category identified by Howard Gardner. This indicates that the students do learn best by performing experiments in a laboratory setting.

Number Smart: This category records an average score of **3** which is not an acceptable score for engineering students. Engineers need to be really very proficient in rigorous mathematical analysis and calculations.

Word Smart: An unacceptable score of **2** in this category indicates the inability of students express to their thoughts using writing as a tool.

Picture Smart: A Likert Scale score of **4** indicates that students do *understand* best when they actually *see* it.

MORE DETAILED DISCUSSION OF THE BAR CHART IS FOUND IN PAGE 8

AN EXAMPLE MATRIX FOR A SINGLE STUDENT:

	5 STR. AGREE	4 AGREE	3 UNDECIDED	2 DISAGREE	1 S. DISAGREE
Picture Smart - Visual Intelligence		√			
Word Smart - Linguistic Intelligence				√	
Number Smart - Mathematical Intelligence		√			
Body Smart - Kinesthetic Intelligence	√				
Music Smart - Rhythmic Intelligence					
People Smart - Interpersonal Intelligence		√			
Self Smart - Intrapersonal Intelligence			√		

APPENDIX B : Matrix Generated for Assesment

Assessment Based on Howard Gardner's Theory of Multiple Intelligences

	TOTAL xx STUDENTS #	A	B	C	.	.	.	.	X	Y	Z	MEDIAN	MODE	AVG.
1	**Self Smart – Intrapersonal Intelligence**	4	4	3	.	.	.	.	4	3	3		2	
2	**People Smart – Interpersonal Intelligence**	3	4	5	.	.	.	.	5	5	5		4	
3	**Music Smart – Rhythmic Intelligence**	-	-	-	.	.	.	.	-	-	-		-	
4	**Body Smart – Kinesthetic Intelligence**	3	3	5	.	.	.	.	4	3	4		5	
5	**Number Smart – Mathematical Intelligence**	3	3	5	.	.	.	.	5	4	4		3	
6	**Word Smart – Linguistic Intelligence**	4	4	5	.	.	.	.	5	4	5		2	
7	**Picture Smart – Visual Intelligence**	4	3	4	.	.	.	.	3	4	3		4	

THE CRITICAL THINKING RUBRIC
RUBRIC COURTESY OF W. S. U.
WASHINGTON STATE UNIVERSITY
PULLMAN, WA. 99164.
LIKERT SCALE WEIGHT DISTRIBUTION :
(1 : Strongly Disagree; 5 : Strongly Agree)

Data Collected by: Mysore Narayanan

The data collected are normally displayed in a bar chart.

It should be observed that the data collected are ordinal. This indicates that they have an inherent order or sequence. It must be interpreted carefully. The data is not continuous.

Therefore it is not appropriate to create a histogram. Mean values do not have any meaning for interpretation. Furthermore *Standard Deviation* does not convey anything.

Reference: http://www.icbl.hw.ac.uk/ltdi/cookbook/info_likert_scale/

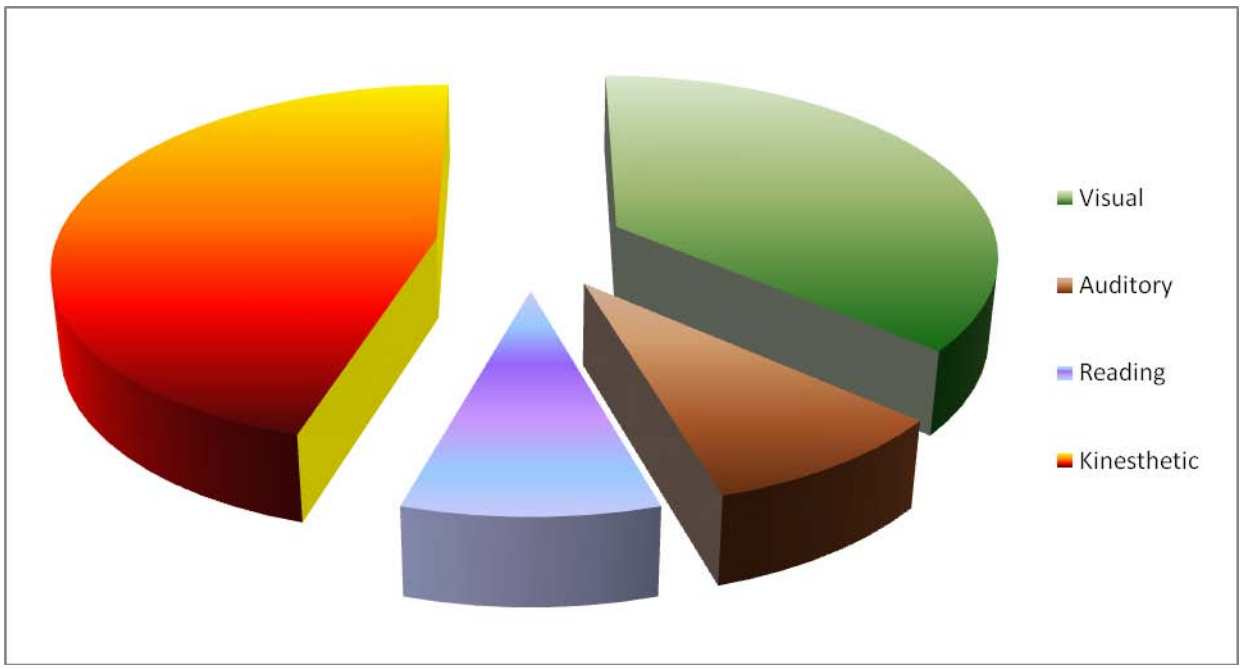
Descriptive Techniques (Likert Evaluation Cookbook 2004)

The data are normally summarized using a median or a mode.

The author prefers *mode* because it is considered to be the most appropriate for this type of data analysis.

APPENDIX C: Comparison Chart

Likert Scale Score	Howard Gardner's Theory of Multiple Intelligences		Fleming & Mills' VARK Learning Styles	Likert Scale Score
4	Picture Smart		Visual	4
2	Word Smart		Auditory	2
2	Self Smart		Reading	2
5	Body Smart		Kinesthetic	5
3	Number Smart			
4	People Smart			
-	Music Smart			



APPENDIX C (Contd.): Analysis of the Pie Chart

A collection of the data gathered and the results have been presented above in an excel format. A pie chart was generated based on the data collected using the *VARK* principles of Fleming and Mills.

Referring to the pie chart shown above:

It can be seen that the *Visual* category recorded a very good value of **4.** This is in excellent agreement with the data collected during the previous experiment. The *Picture Smart* category defined by Howard Gardner recorded a Likert Scale score of **4** indicating that students do *understand* best when they actually *see* it.

The *Auditory* mode of learning recorded a low score of **2.** Again, this is in excellent agreement with the *Likert Scale Score* of **2** that was recorded for *Self Smart* category identified by Howard Gardner.

The third category, *Reading* mode of learning recorded a low score of **2.** Again, this is in excellent agreement with the *Likert Scale Score* of **2** that was recorded for *Word Smart* category identified by Howard Gardner.

Finally, the maximum possible mode value of **5** was recorded for *Kinesthetic* style of learning. This again, is in excellent agreement with Likert Scale score of **5** that was accomplished in the *Body Smart* category identified by Howard Gardner.

The above analysis shows that *Kinesthetic* mode is perhaps the best possible venue for engineering students. Regardless, one should recognize that in reality learners are actually *multimodal.* In other words, many learners may prefer *multiple* modes, instead of a single one.

In addition, some students may be *context specific.* This indicates that they prefer to select the mode best suited to a given discipline. Some may take longer time to gather and absorb from a chosen mode. This will ultimately lead to a better understanding in depth as well as breadth. Some other learners may insist that they need to receive information in all of their preferred modes.

The author has also drawn from Hunter Boylan's research and has tried to compare his data with those of Boylan. Hunter Boylan also concludes that only about eleven percent of learners are auditory learners. This comparison chart is shown in Appendix G. The author acknowledges that his engineering discipline is completely different from that of Dr. Hunter Boylan. However, the data gathered by the author is strikingly similar to the data presented by Boylan.

APPENDIX D: Author's Data Compared with those of Hunter Boylan

	VISUAL	AUDITORY	READING	TACTICAL CONCRETE KINESTHETIC
BOYLAN'S RESEARCH	86%	11%		3%
AUTHOR'S DATA	MODE = 4	MODE = 2	MODE = 2	MODE = 5

Source:

1. Fleming, N. D. & Mills, C. (1992). *VARK a guide to learning styles.* http://www.vark-learn.com/English/index.asp

2. Boylan, H. R. (2002). *What Works: Research-Based Best Practices in Developmental Education*. Boone, NC: National Center for Developmental Education.

MATRIX USED BY THE AUTHOR

Assessment of Four VARK Styles (Spring 2010)

TOTAL xx STUDENTS #	A	B	C	D	E	F	G	H	I	J	K	L	.	.	.	X	Y	Z	MEDIAN	MODE
Visual	4	5	3	4	3	3	2	3	5	4	2	2	.	.	.	4	2	4		4
Aural	3	2	2	2	3	2	2	2	3	2	3	2	.	.	.	3	2	3		2
Reading	3	2	2	4	2	3	2	2	2	3	2	3	.	.	.	2	2	2		2
Kinesthetic	5	4	5	5	5	5	4	5	4	5	4	5	.	.	.	5	5	4		5

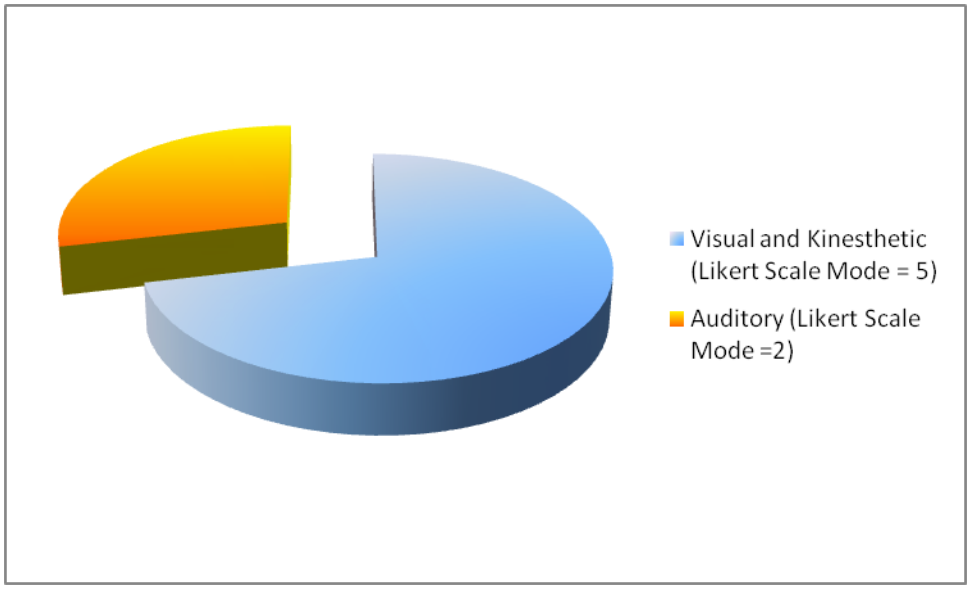
RUBRIC COURTESY OF W. S. U.
WASHINGTON STATE UNIVERSITY
PULLMAN, WA. 99164.
LIKERT SCALE WEIGHT DISTRIBUTION
(1: Strongly Disagree; 5: Strongly Agree)

APPENDIX D (Contd.): Boylan's Research and Author's data.

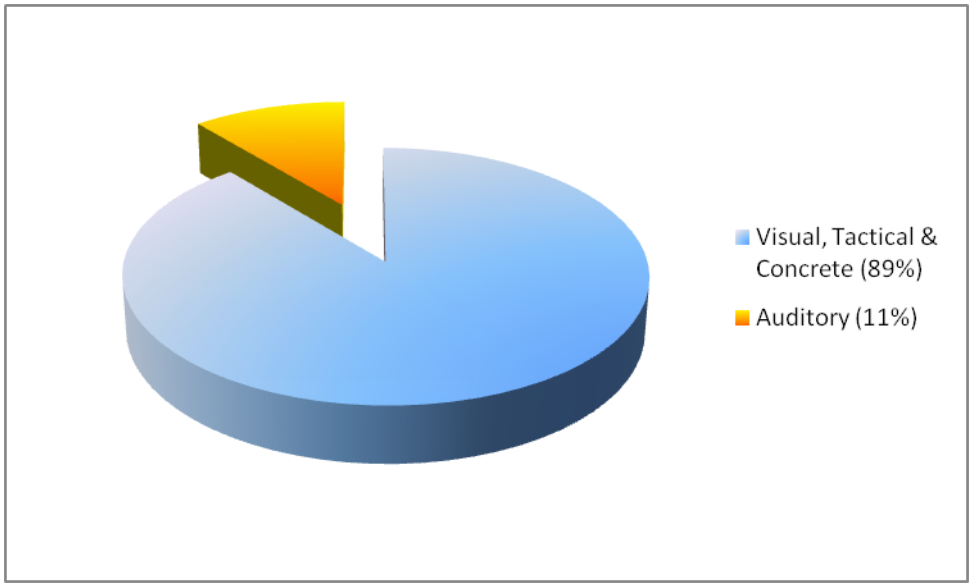
Source: Fleming, N. D. & Mills, C. (1992). *VARK a guide to learning styles.* http://www.vark-learn.com/English/index.asp

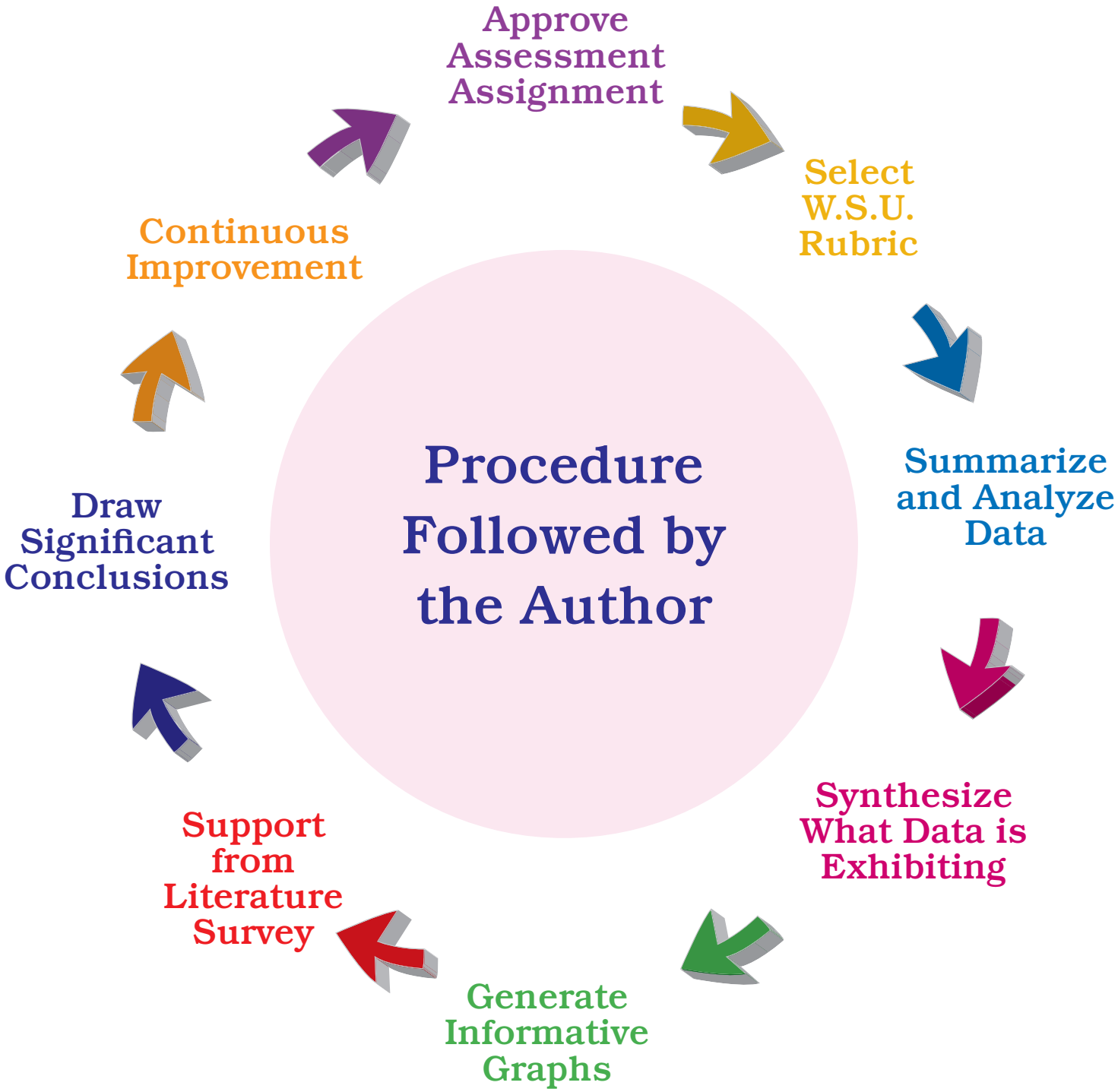
Boylan, H. R. (2002). *What Works: Research-Based Best Practices in Developmental Education.* Boone, NC: National Center for Developmental Education.

AUTHOR'S DATA



BOYLAN




Approve Assessment Assignment
Select W.S.U. Rubric
Summarize and Analyze Data
Synthesize What Data is Exhibiting
Generate Informative Graphs
Support from Literature Survey
Draw Significant Conclusions
Continuous Improvement
Procedure Followed by the Author

APPENDIX F : Rubrics courtesy of W S U, Pullman, WA.

	Rubrics based on Likert Scale	
5	Has demonstrated excellence. Has provided documentation. Evidence of critical thinking ability. Very good performance	Has analyzed important data precisely. Has answered key questions correctly. Has addressed problems effectively. Has evaluated material with proper insight. Has used deductive reasoning skills. Has used inductive reasoning skills. Has employed problem solving skills. Has discussed consequences of decisions. Has been consistent with inference.
3	Has demonstrated competency. Adequate documentation. Critical thinking ability exists. Acceptable performance.	Data analysis can be improved. More effort to address key questions. Need to address problems effectively. Expand on evaluating material. Improve deductive reasoning skills. Improve inductive reasoning skills. Problem solving skills need honing. Must discuss consequences of decisions. Has been vague with inference.
1	Poor, unacceptable performance. Lacks critical thinking ability.	Absence of analytical skills. Answers questions incorrectly. Addresses problems superficially. Lacks documentation. Inability to evaluate material. Shows no deductive reasoning power. Inductive reasoning power non existent. Poor problem solving skills Unaware of consequences of decisions. Unable to draw conclusions.

Source:

Narayanan, Mysore. (2009). *Assessment Based on the principles of Theodore Marchese.* ASEE 116th Annual Conference and Exposition, Austin, TX. June 14–17, 2009. Paper # AC 2009-1532.

APPENDIX G: LIKERT SCALE BAR CHART ANALYSIS

1. Identification of problem has scored a **4** on the Likert scale, which is an acceptable rating. Students are capable of recognizing the problem on hand. However, an attempt must be made to improve this to the maximum possible level of **5.**

2. There is room for improvement in the second category that pertains to context. A Likert scale score of **3** is not adequate. Engineers should learn to correlate better and one should try to improve this to a level of **4** at least.

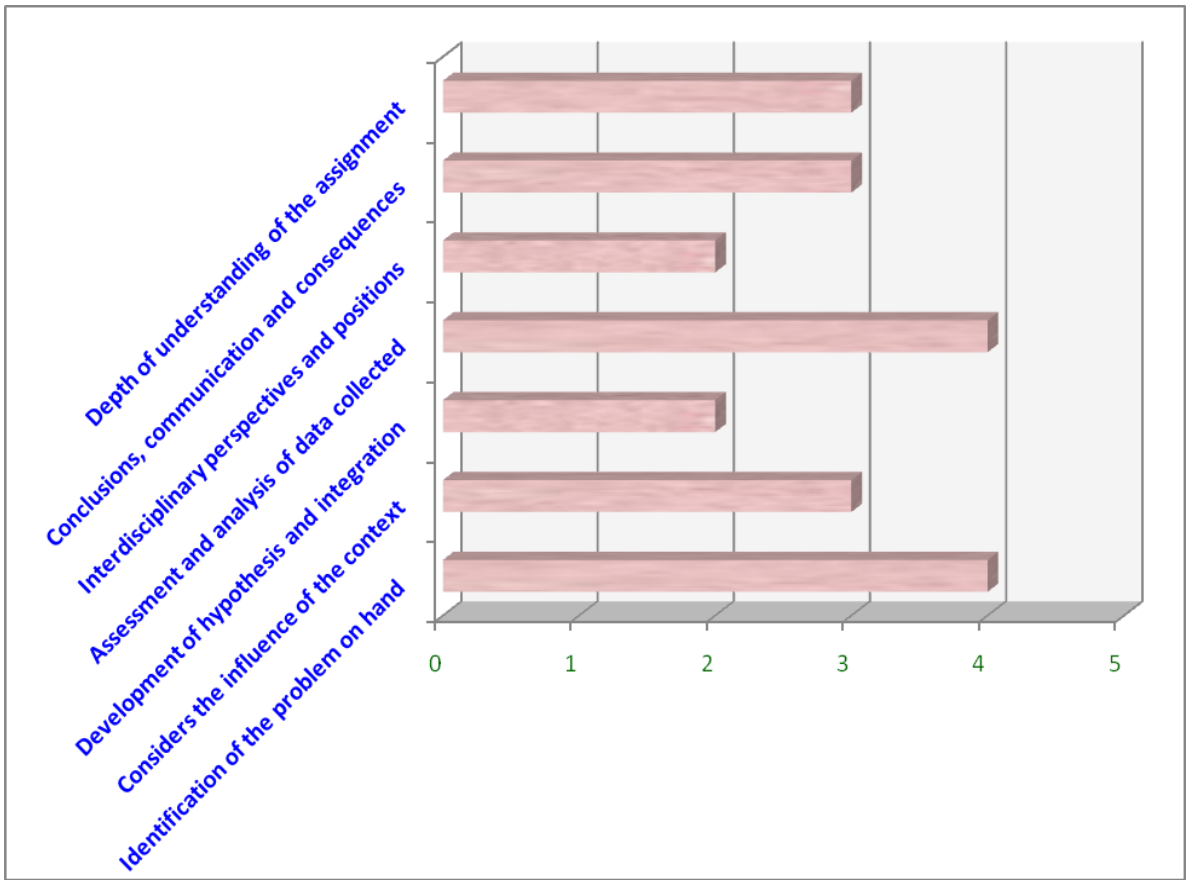
3. Much more effort is needed while the student develops hypotheses. A score of **2** is unacceptable because integration is the key to success in any endeavour.

4. Data analysis shows a respectable mode value of **4.** The students are proficient in presenting the data, with the help of computer software like EXCEL and MATLAB.

5. A mode value of **2** indicates that more progress is to be made in this area. Interdisciplinary perspectives are quite difficult to accomplish when the students are extremely busy with a college curriculum.

6. Conclusions and communication must be improved to record at least **4.** Visual, vocal and verbal communication skills are essential for the 21st century engineer.

7. A score of **3** indicates students need to *understand* what is expected of them. One should try to improve this to a score of **4** and preferably to **5** ultimately.



APPENDIX H: Gregoric Style Delineator: Four learning styles

The following represents a brief description of each of the four learning styles.

Concrete Sequential (CS) These learners prefer direct, hands-on experience. They exhibit extraordinary development of their five senses. They like touchable, concrete materials, and orderly presentations. CS's actually enjoy faculty meetings! They are adverse to change and do not oppose tradition. They are habitual, punctual, and desire perfection. You would not see a CS wear flashy colors or mismatched outfits. They are organized, desire perfection, and give "practical" gifts.

Abstract Random (AR) These learners have a capacity to sense moods, and they use intuition to their advantage. They prefer to learn in an unstructured environment such as group discussions and activities. Faculty meetings are viewed as a time to socialize! They prefer not to be restricted by unnecessary rules and guidelines. Because AR's continuously discharge energy, they may appear "hyper" when indeed they are not. AR's use hand and body movements when communicating. They dislike routine activities and cold, unemotional people.

Abstract Sequential (AS) These learners have excellent abilities with written, verbal, and image symbols. They like to read, listen, and use their visual skills. They are highly verbal; therefore, you will never have a short conversation with an AS. They prefer a sequential presentation that is rational and substantive or they consider meetings a waste of time. AS's are "fence straddlers" and highly skeptical.

Concrete Random (CR) These learners like to experiment using trial-and-error approaches. They tend to jump to conclusions and prefer to work independently or in small groups. They are gamblers and risk takers. CR's may arrive late to meetings and leave early if they feel the meeting is boring or going nowhere. Concrete Random individuals are leaders, not followers. They love to take charge and be in charge. They refuse to accept the words "don't" or "can't." They thrive in a competitive atmosphere. CR's are not overly concerned with making impressions or going out of their way to win over people. They are often the prime movers of change.

Source:

1. Gregorc, A. F., & Ward, H. B. (1977). *Implications for learning and teaching: A new definition for individual.* NASSP Bulletin, 61, 20-26.

2. Gregorc, A. F. (1979). *Learning styles: Differences which the profession must address.* Reading through content, 29-34.

3. Gregorc, A. F. (1979). *Learning/teaching styles: Their nature and effects.* Student learning styles: Diagnosing & prescribing programs, 19-26.

4. Gregorc, A. F. (1984). *Style as a symptom: A phenomenological perspective.* Theory into Practice, *23*(1), 51-55.

5. Gregorc, A. F., & Ward, H. B. (1977, February). *A new definition for individual.* NASSP Bulletin.

References:

1. Aiken, L. R. (2000). *Psychological Testing and Assessment (10th Edition).* Boston, MA: Allyn and Bacon.

2. Aiken, L.R. (1997). *Questionnaires & Inventories: Surveying Opinions and Assessing Personality.* New York: John Wiley.

3. Armstrong, Thomas. (1994). *Multiple Intelligences in the Classroom.* Alexandria, VA: Association for Supervision and Curriculum Development.

4. Barbe, Walter B. , Milone, Michael N., Jr. (1980). *Modality.* Instructor, 89, 44-47.

5. Barbe, W. And R. Swassing (1979). *Swassing-Barbe Modality Index.* Columbus, OH: Zaner- Bloser.

6. Borasi, R., Siegel, M., Fonzi, J., & Smith, C. (1998). *Using transactional reading strategies to support sense-making and discussion in mathematics classrooms: An exploratory study.* Journal for Research in Mathematics Education (29), 275-305.

7. Boylan, H., Bliss, L., & Bonham, B. (1997). Program components and their relationship to student success. Journal of Developmental Education, 20(3), 2-4, 6, 8.

8. Boylan, H.R., Bonham, B.S., Clark-Keefe, K., Drewes, S., & Saxon, D.P. (2004). Forging new partnerships. Adult and developmental education in community colleges. Working Paper 8. CAAL Community College Series. New York, NY: Council for Advancement of Adult Literacy.

9. Carbo, M., & Hodges, H. (1988, Summer). *Learning styles strategies can help students at risk.* Teaching Exceptional Children, 48 – 51, 65 – 78.

10. Dunn, R., & Dunn, K. (1987). *Understanding learning styles and the need for individual diagnosis and prescription.* Columbia, CT: The Learner's Dimension.

11. Dunn, R. & Dunn, K. (1979). *Learning Styles/Teaching Styles: Should They… Can They … Be Matched*. Educational Leadership, January.

12. Fernald, G. M. (1943). *Remedial techniques in basic school subjects.* New York: McGraw-Hill.

13. Fernald, G. M., & Keller, H. (1921). *The Effect of Kinaesthetic Factors in the Development of Word Recognition in the Case of Non-Readers.* Journal of Educational Research, 4, 355-377.

14. Fleming, N. D. & Mills, C. (1992). *VARK a guide to learning styles.* http://www.vark-learn.com/English/index.asp

15. Gardner, Howard (1983). *Frames of Mind: The Theory of Multiple Intelligences. 10th Anniversary Edition.* New York: Basic.

16. Gardner, Howard (2000). *Intelligence Reframed: Multiple Intelligences for the 21st Century*. New York: Basic.

17. Gardner, H., & Hatch, T. (1989). *Multiple intelligences go to school: Educational implications of the theory of multiple intelligences.* Educational Researcher, 18(8), 4-9.

18. Grasha, A.F. (1996). *Teaching with style.* Pittsburgh, PA: Alliance Publishers

19. Gregorc, A. F., & Ward, H. B. (1977). *Implications for learning and teaching: A new definition for individual.* NASSP Bulletin, 61, 20-26.

20. Keefe, J. W. (1991). *Learning style: Cognitive and thinking skills.* Reston, VA: National Association of Secondary School Principals.

21. Keefe, J. W. (1988). *Profiling and utilizing learning style.* Reston, VA: National Association of Secondary School Principals.

22. Keefe, J. W. (1987). *Theory and practice.* Reston, VA: National Association of Secondary School Principals.

23. Kirk S A, McCarthy J & Kirk W D. *The Illinois test of psycholinguistic abilities.* Urbana, IL: University of Illinois Press, 1967. 136 p.

24. Kolb (1985) *Learning Styles Inventory*. Boston, MA: TRG Training Resource Group.

25. Marchese, T.J. (1991). *TQM reaches the academy.* AAHE Bulletin, 44, 3-9.

26. Marchese, T.J. (1997). *The new conversations about learning.* In Assessing Impact: Evidence and Action. Washington DC: American Association for Higher Education.

27. Narayanan, Mysore (2009) *Assessment Based on the Principles of Theodore Marchese.* Proceedings of ASEE National Conference, Austin, Texas.

28. Penno, J., Wilkinson, I., & Moore, D. (2002). *Vocabulary acquisition from teacher explanation and repeated listening to stories: Do they overcome the Matthew effect?* Journal of Educational Psychology, 94, 23-33.

29. Sternberg, R. J. (1994). *Allowing for thinking styles.* Educational Leadership, *52*(3), 36-40.

30. Watkins, Angela Farris (2005). *Using Learning Styles in College Thinking.* Journal on Excellence in College Teaching. 16(3), 83-101.

WEBSITES

1. *http://telr.osu.edu*

2. http://wsuctproject.wsu.edu/ctr.htm

3. http://www.pz.harvard.edu/PIs/HG.htm

4. http://www.icbl.hw.ac.uk/ltdi/cookbook/info_likert_scale/

5. http://www.discountutor.com/