AC 2009-1532: ASSESSMENT BASED ON THE PRINCIPLES OF THEODORE MARCHESE

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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 more than a dozen 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 assessments that enhance students' critical thinking capabilities.

Assessment of Engineering Education based on the Principles of Theodore Marchese

Mysore Narayanan, Miami University, Ohio.

Abstract

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). All of which is to say, assessment is more than data gathering. It also encompasses essential functions of meaning-making, action, and commitment to improve. Absent any of these elements, the doing of assessment becomes hollow. Ted 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. He is also a trustee of *Eckerd College* and of the *Transnational 21st Century Learning Initiative.* While at AAHE he edited *Change* (higher education's most-read magazine), the *AAHE Bulletin*, and directed a foundation-supported project that resulted in his widely praised publication, "The Search Committee Handbook." Assessment as *'learning'* is not a third-party research project or someone's questionnaire; it must be viewed as a community effort or nothing, driven by a faculty's own commitment to reflect, judge, and improve. In this presentation the author provides some guidelines for conducting assessment utilizing the principles outlined by Theodore Marchese.

Introduction

Quarter of a Century ago, in 1983, Harvard University Professor Howard Gardner introduced the theory of Multiple Intelligences. Dr. Gardner suggested that the Intelligence Quotient, IQ alone should not become the primary basis for measuring human potential. (Narayanan, 2007, 2008).

Howard Gardner proposed that there are seven broad areas wherein children and adults can excel and listed them as follows (Armstrong, 1993). There is a possibility of adding three more.
They are: Naturalist Intelligence, Spatial Intelligence and Existential Intelligence.

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

Howard Gardner is the Director of Harvard Project Zero and Professor of Cognition and Education at the Harvard Graduate School of Education. He has received numerous honors and written dozens of books (Gardner, 1983). Howard Gardner was the first American to receive the *University of Louisville's Grawemeyer Award in Education.* Dr. Howard Gardner is best known in educational circles for his theory of multiple intelligences, a critique of the notion that there exists but a single human intelligence that can be assessed by standard psychometric instruments (Gardner, 1993). During the past twenty-five years, he and colleagues at Project Zero have been working on the design of performance-based assessments, education for understanding, and the use of multiple intelligences to achieve more personalized curriculum, instruction, and assessment. (Narayanan, 2007, 2008). (http://www.pz.harvard.edu/PIs/HG.htm)

In this presentation, the author describes how he has implemented, incorporated and assessed Howard Gardner's ideas when applied to teaching a subject matter in the area of manufacturing engineering. The author has utilized *Washington State University's Critical Thinking Rubrics* to accomplish this task. (Narayanan, 2007, 2008). The author believes that this can lead to interesting findings and observations (Dunn & Dunn, 1979). The author however acknowledges the fact that it is very important to create significantly different learning environments, particularly for engineering students. Details pertaining to implementation are documented on page 6 and in the appendices.

Perceptual Modality

Dr. Walter B. Barbe, a nationally known authority in the fields of reading and learning disabilities 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. (Barbe & Milone, 1981). 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).

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. (Narayanan, 2007, 2008). 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). 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).

Fleming & Mills' VARK Learning Styles

The author believes it is important to recognize other researchers who have also contributed in the area of cognitive science, educational psychology and educational methodologies. The author presented these findings at the 2007 ASEE National Conference in Honolulu, Hawaii. Part of it has been reproduced here, below for the sake of clarity and completeness (Narayanan, 2007, 2008). 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) suggested four categories that seemed to identify students' learning behavior.

[Copyright for VARK version is held by Neil D. Fleming, Christchurch, New Zealand and Charles C. Bonwell, Green Mountain, Colorado, USA].

Visual (V)

Certain groups of learners prefer when material is in a *visual* form and for these learners retention is better when they actually *see* something. This perceptual mode is referred to as *Visual* mode. Some students may learn faster when information is presented to them in the form of diagrams, tables, graphs, charts, etc. Here one may mention the famous proverb: *A picture is worth a thousand words.*

Auditory (A)

Some other learners enjoy being *speakers* and also actively participate when others speak. This perceptual mode is referred to as *Auditory* mode. These types of students may be better at the *aural* category. Some learners may prefer being lectured to. These types of learners like to participate in group discussions and would like to *talk things through.*

Read (R)

Academics may prefer this category of read and write. This is the third group of students who *may* be better at the *read* category. This category implies and includes *write* category as well. It is all too well known that instructors ask the students *"Read Chapter 7 from the textbook before coming to next class meeting."* Some other instructors ask the students to write, for example, *"A 400-word essay about French Revolution."* In other words, the input to the student is text-based and the output from the student is also text-based. This perceptual mode is referred to as *Read* mode.

Kinesthetic (K)

Some people learn only by *doing*. They need *hands-on-training*. Here one may want to quote the famous phrase: *Practice Makes You Perfect.* This last, final group prefers to learn through experience. It could be laboratory experience, clinical experience, simulation, co-op experience, industrial internship experience, service-learning experience, practical training experience, etc. This perceptual mode is referred to as *Kinesthetic* mode.

Hunter Boylan's Research Findings

Again, the author believes that it is very important to recognize those researchers who have also contributed in the area of cognitive science, educational psychology and educational methodologies. 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 alterative forms of instruction if they are expected to use diverse instructional methods. (Narayanan, 2007). 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. (Appalachian State University's NCDE: National Center for Developmental Education)

Paul Nolting's Research

Another scholar, Dr. Paul Nolting, Title III Coordinator at Manatee Community College Bradenton, Florida 34207 has compared
Student Learning Styles of Developmental Math Students to *Faculty Learning Styles.*

In his publication Dr. Paul Nolting concludes:

"It would be a mistake to think that the only problem under prepared students has is their knowledge base (McCabe, 2003). The idea of learner-centered education is that students must make a connection between the content and their perception of learning (Perin, 2001). To help students better understand their learning, some institutions have attempted to help students define their own learning style by giving them different learning styles inventories."

Dr. Paul Nolting also comments that:

"By identifying student learning styles and dissemination styles, then students have a better chance to identify with a delivery method that most closely aligns with their ability

to learn (McCabe, 2003). Also faculty would have a better understanding on how their students learn in order to modify some of their delivery methods."

Using these suggestions provided by eminent scholars like Paul Nolting, Hunter Boylan, Howard Gardner, Fleming and Mills, faculty can actually introduce many changes into the classroom that can document to have a positive effect on student learning. Research by Dr. Hunter R. Boylan indicates that there are 86% visual learners, 11% auditory learners and 3% tactical-concrete learners. (Boylan 2002). The author has compared his data with those of Hunter Boylan in one of his recent publications (Narayanan, 2007).

Ohio State University's TELR:

The author also believes that it is very appropriate to mention about the research that is being carried out at the Ohio State University.

At Ohio State University in Columbus Ohio, ***Technology Enhanced Learning and Research*** *(TELR) reports directly to the Office of the Chief Information Officer (CIO). At the heart of TELR is the TELR Design Team, a team of highly skilled professionals comprising instructional technologists, visual and web designers, web programmers, accessibility specialists, and researchers. The team provides Ohio State's academic community and its external partners with scalable, end-to-end eLearning and visual communication solutions.* (*http://telr.osu.edu/)*

There is a very famous and powerful Adage:

"Teach me and I forget."
"Show me and I may remember."
"Involve me and I will learn."

The principle is to change classroom teaching styles from a teaching environment to an atmosphere that promotes learning paradigm. One may extend this principle further, to mention that final approach should be in the form of *"Discovery and Metacognition."* (Narayanan, 2008). The role of the instructor will be more like a facilitator of a learning environment. The facilitator should try to accommodate something similar to *VARK* learning styles for the benefit of the learners (Narayanan, 2007).

Authors, Alexander W. Astin, Trudy W. Banta, K. Patricia Cross, Elaine El-Khawas, Peter T. Ewell, Pat Hutchings, Theodore J. Marchese, Kay M. McClenney, Marcia Mentkowski, Margaret A. Miller, E. Thomas Moran and Barbara D. Wright developed a document in 1996 under the auspices of the AAHE (American Association for Higher Education) Assessment Forum with support from the Fund for the Improvement of Postsecondary Education with additional support for publication and dissemination from the Exxon Education Foundation. These nine authors have generated a list of nine principles that the readers can obtain from the website given below.

http://www.fctel.uncc.edu/pedagogy/assessment/9Principles.html

American Association for Higher Education
Principles of Good Practice for Assessing Student Learning

1. The assessment of student learning begins with educational values.

2. Assessment is most effective when it reflects an understanding of learning as multidimensional, integrated, and revealed in performance over time.

3. Assessment works best when the programs it seeks to improve have clear, explicitly stated purposes.

4. Assessment requires attention to outcomes but also and equally to the experiences that lead to those outcomes.

5. Assessment works best when it is ongoing not episodic.

6. Assessment fosters wider improvement when representatives from across the educational community are involved.

7. Assessment makes a difference when it begins with issues of use and illuminates questions that people really care about.

8. Assessment is most likely to lead to improvement when it is part of a larger set of conditions that promote change.

9. Through assessment, educators meet responsibilities to students and to the public.

Implementation and Assessment

At Miami University, the author has tried to implement ideas from all these researchers and scholars into practice using modern technology. This includes the World Wide Web, I.V.D.L. (Interactive Video Distance Learning) in addition to regular and routinely used audio visual techniques such as power point presentations, tutorials, problem-solving sessions, written research reports, peer group discussions, etc. The author utilizes a variety of instructional tools to communicate with students who may prefer to have different learning styles (Kolb, 1985). The authors also recommend that students utilize the resources that are readily available at the university, such as *Library. Writing Center,* etc. (Narayanan, 2007).

Appendix A shows how *Assessment of Manufacturing Engineering Education* was carried out. The grading was administered using *Washington State University's Rubric.* A sample of grading scheme is shown in Appendix B & C. The data obtained was tabulated using a Likert Scale. Several *"Primary Traits"* or *"Characteristics"* were

identified and assessed. Appendix D documents this data collected using a bar chart. It is desirable to achieve mode values of 5 on all the seven characteristics; however this is probably unrealistic in an undergraduate environment. (Narayanan, 2007).

The author would like to state that *Washington State University's Critical Thinking Rubric* has proved to be extremely valuable in documenting the effectiveness of systematic use of assessment methods. [http://wsuctproject.wsu.edu/ctr.htm]

This has helped the instructor address and assess multiple intelligences and multiple dimensions of learning and thereby giving the learning environment facilitators proper guidance for moving in the *right direction.* It is important to identify the ultimate goal. It is to deliver information to students in the best possible manner that suits the receiver's optimum learning style (Narayanan, 2007).

Conclusions

It is easily seen from the bar chart that the two "traits"

Characteristic #1 (Documentation of Principles, Laws and Fundamental concepts) and
Characteristic #4 (Effective presentation and accurate analysis of data)

both show respectable mode values of 5.

Furthermore, two other characteristics show mode values of 4. These are:

Characteristic #2 Assesses, Analyzes and addresses consequences effectively.
Characteristic #3 Appropriately integrates with relevant issues.

However, the other three characteristics show mode values of 3 indicating that there is room for improvement:

Characteristic #5 (Logical arguments and development of hypothesis)
Characteristic #6 (Recognition of the need and appropriate context.) and
Characteristic # 7 (Depth of understanding of the subject matter)

Appendix F shows a *"VARK"* bar chart, based on Fleming and Mills' ideas. (Narayanan, 2007).

It can be seen that an excellent mode value of 5 was recorded for "Kinesthetic" style of learning. "Reading" style recorded a low score of 2. "Aural" also has a value of 2 whereas "Visual" had a modest value of 4. The author agrees and understands that these data may *vary significantly* depending upon subject matter, instructor's delivery styles, material content, discipline etc. It is possible that *Kinesthetic Mode* of learning may be preferred by students engineering disciplines whereas *Reading Mode* of learning may be best suited for students in English literature (just for example).

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.* It is very important to recognize that our data is significantly different from Hunter Boylan's research. The author acknowledges that his engineering discipline is different from that of Dr. Hunter Boylan. However, a comparison chart is shown in Appendix G. 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. (Narayanan, 2007).

Acknowledgements

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APPENDIX A : Assessment of Manufacturing Engineering Education.
(Narayanan, 2007).

Students were not provided with a questionnaire to fill out.

Rationale: Students are exhausted in filling out forms.

Some researchers are of the opinion that 'questionnaire-fatigue' may result in faulty or skewed data.

If so, how was assessment carried out?

The instructor delivered four content materials in four different modes.

Topic 1 was delivered in the Lecture Format. (Aural)

Topic 2 utilized Power Point Slides and other Visual Aids. (Visual)

Topic 3 was left to the students to read, write and submit their findings. (Reading)

Topic 4 was handled like a laboratory, demonstration, discussion, etc. (Kinesthetic)

The four topics chosen were fairly similar in their complexity, although not exactly identical. (The instructor realizes and agrees that one topic may be tougher for the student to understand than another topic, example.)

Later, the students were examined on all the four topics. Instructor graded the test and documented his observations. Grading was holistic and qualitative. No quantitative grade points or percentages were recorded. Grading was recorded based on student's perception, grasp and depth of understanding of the topic.

Rubrics based on Likert Scale (Courtesy of W.S.U.) is shown in Appendix B.

A sample of grading scheme is shown in Appendix C.

Results gathered are represented in a bar chart shown in Appendix D.

Assessment of Four Perceptual Modal Styles is shown in Appendix E.

Appendix F shows the *"VARK"* bar chart based on Fleming and Mills' ideas.

A comparison between Dr. Boylan's research and author's data is shown in Appendix G.

APPENDIX B (Rubrics courtesy of W S U, Pullman, WA) (Narayanan, 2007).

	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.

APPENDIX C : Principles of Grading using W.S.U. Rubrics (Narayanan, 2007).

Assessment of Manufacturing Engineering

TOTAL xx STUDENTS #	A	B	C	.	.	.	.	X	Y	Z	MEDIAN	MODE	AVG.

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)

1	Principles, Laws and Fundamental concepts	4	4	3	.	.	.	.	4	3	3	5
2	Analyzes and addresses consequences effectively	3	4	5	.	.	.	.	5	5	5	4
3	Appropriately integrates with relevant issues	5	4	3	.	.	.	.	3	4	5	4
4	Effective presentation and accurate analysis of data	3	3	5	.	.	.	.	4	3	4	5
5	Logical arguments and development of hypothesis	3	3	5	.	.	.	.	5	4	4	3
6	Recognition of the need and appropriate context	4	4	5	.	.	.	.	5	4	5	3
7	Depth of understanding of the subject matter	4	3	4	.	.	.	.	3	4	3	3

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)

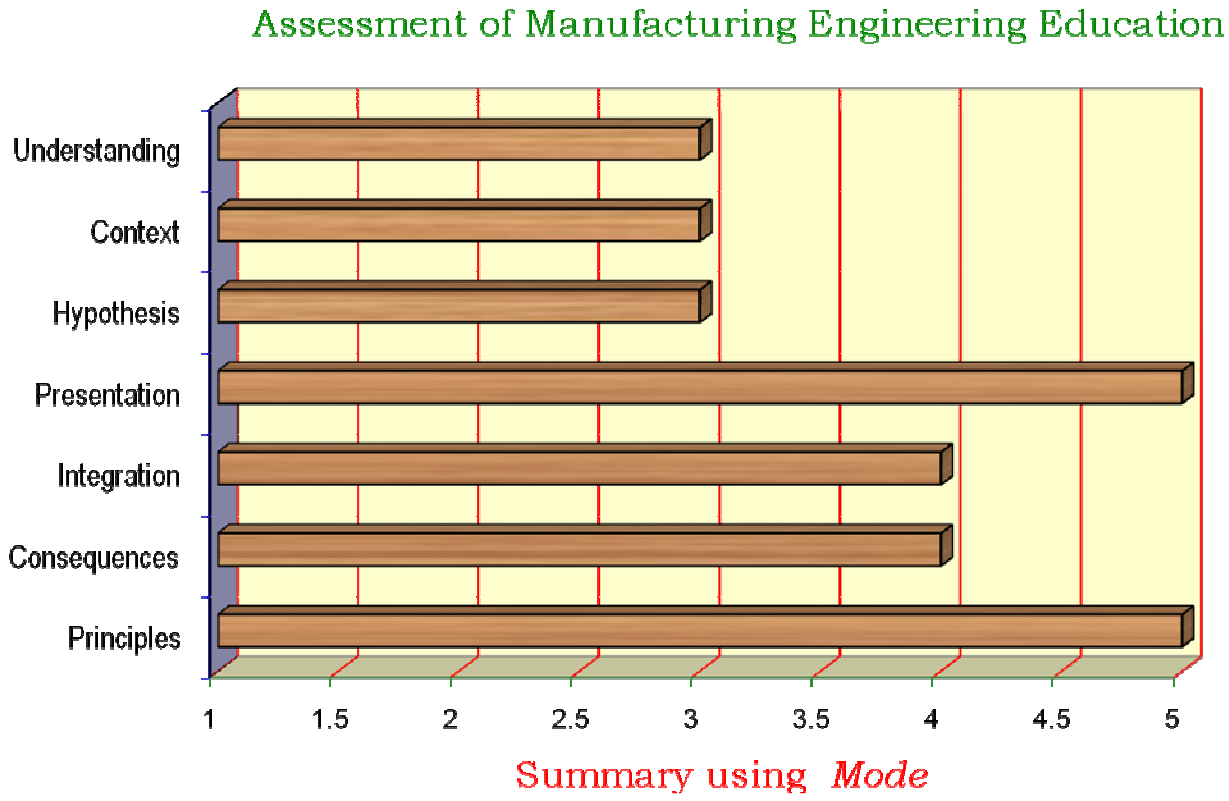
The data are normally summarized using a median or a mode.

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

APPENDIX D Data Collected by the Author is being displayed using a bar chart. (Narayanan', 2007).

Rubrics courtesy of W S U, Pullman, WA

1. Documentation of Principles, Laws and Fundamental concepts
2. Assesses, Analyzes and addresses consequences effectively.
3. Appropriately integrates with relevant issues.
4. Effective presentation and accurate analysis of data.
5. Logical arguments and development of hypothesis.
6. Recognition of the need and appropriate context.
7. Depth of understanding of the subject matter.



APPENDIX E (Rubrics courtesy of W S U, Pullman, WA) (Narayanan, 2007).

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

Assessment of Four
Perceptual Modality Styles

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

Data Collected by:
Mysore Narayanan.

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)

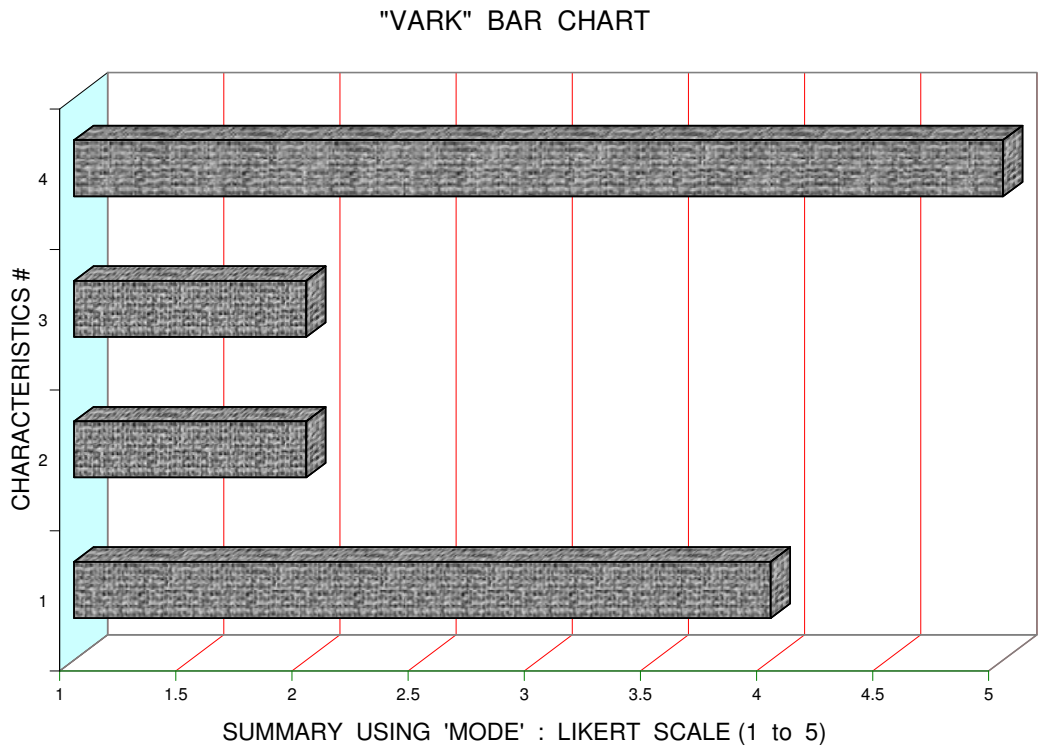
The data are normally summarized using a median or a mode.

The author prefers *mode* because it is considered to be the most appropriate for this type of data analysis.
The data collected are normally displayed in a bar chart.

APPENDIX F : Data collected is displayed using a *Bar Chart.* (Narayanan, 2007).

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

4. Kinesthetic
3. Reading
2. Aural
1. Visual



APPENDIX G (Comparison between Hunter 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
(Narayanan, 2007).

Research by Dr. Hunter R. Boylan (Boylan 2002)		Author's Data
86%	Visual	Mode = 4
11%	Auditory	Mode = 2
	Reading	Mode = 2
	Kinesthetic	Mode = 5
3%	Tactical-Concrete	

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

Sometimes, in engineering disciplines "Kinesthetic" and "Visual" may slightly *overlap.*

In a laboratory setting, the students can actually "see and observe" certain operations when they "perform" experiments.

See and observe may be interpreted *as visual. Perform* may be interpreted as *Kinesthetic.*

Therefore, a laboratory session of 2 or 3 hours' duration can be classified as *Visual or Kinesthetic.*

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