AC 2011-307: ASSESSMENT OF ENGINEERING TECHNOLOGY EDUCATION USING A LEARNING PARADIGM APPROACH

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Abstract

In this presentation, the author describes how one can assess certain specific topics in the area of engineering technology education based on the principles outlined by leading scholars in the area of cognitive science and educational methodologies. The principle is to creatively utilize *Washington State University's Critical Thinking Rubrics* to accomplish this task of documenting assessment. Here one would like to stress the fact 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 the student's learning style. One should also focus on a well-established fact that student learning is actually an interactive process that takes place in educational environment established specifically to promote and enhance knowledge in a *discovery atmosphere.* Furthermore, researchers 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 student. Research also points out that those problems related to learning most frequently are *not* related to the complexity of the subject matter. Problems related to learning may actually relate to the level of cognitive process that is absolutely essential to master the material at the required level. Walter Barbe, a nationally known authority in the fields of reading and learning disabilities, who has shown that perceptual modality styles do indeed provide an indication of an individual's dominant learning mode. One should acknowledge the fact that it is very important to create significantly different learning environments, particularly when one is in charge of teaching industrial engineering technology students.

Introduction

Assessment helps us understand which students learn best under what conditions. Over the past several years, the author has experimented on a wide variety of research projects and has collected lot of data on several topics of interest. He has also reported on his findings at a number of other ASEE conferences (Narayanan, 2007, 2008). As a part of the literature survey, some of the paragraphs have been reproduced here for sake of clarity and completeness. In this particular presentation, he draws from the experience and expertise he has gathered over several years of research.

According to guidelines proposed by the American Association for Higher Education (AAHE Assessment Forum, 1992 http://ultibase.rmit.edu.au/Articles/june97/ameri1.htm):

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

In other words, the important aspect to observe here is that one has to move away from a teaching paradigm to learning paradigm. The author takes this philosophy further, and says:

"Students should learn using a discovery approach."

Clifford O. Young, Sr., & Laura Howzell Young of California State University, San Bernardino argue that a new paradigm for assessment, a learning paradigm, must be constructed to measure the success of new kinds of educational practices (Young and Young, 1999).

1. The participants should be capable of selecting an assessment plan best suited for their discipline and execute the chosen plan using a methodical approach.

2. The participants should be capable of developing a set of rubrics that can be effectively utilized in administering their assessment procedures.

3. The participants should finally be able to generate a set of graphs that provide them with appropriate feedback pertaining to student learning capabilities.

Information Processing

It is important to acknowledge that students learn better, when alternative modes of information processing are made available at college campuses (Hunter Boylan, 2002). Fleming and Mills suggested four 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 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 1980 and 1981; Howard Gardner, 1993). The author proposes that learning activities generated based on the principles of Fleming and Mills provide a strong background for the understanding of fundamental knowledge (Dunn & Dunn, 1978). The instructor should design and develop four activities that can be delivered in four *perceptual* modes.

It is also important to recognize that *Learning* is an interactive process that has three important components.

- The Learner,
- The Instructor and
- The Learning Environment.

James W. Keefe is the president of the *Learning Environments Consortium International* and is an educational writer who has taught at the University of Southern California and Loyola Marymount University. Keefe indicates that these three activities show a wide variation in behavior pattern, instructional quality and delivery styles (Keefe, 1987). Educators must be reformulating *Teaching Styles* so that they can closely relate to *Learning Styles* in order to successfully address the needs of the student (Gregorc and Ward, 1997). One may also mention the famous case of Tinker vs. Des Moines Independent Community School District, which concerns itself with students' rights. Keefe also suggests that instructors should be creative to base the programs on the differences that exist among students. It is incorrect to assume that everyone learns in an identical manner (Keefe, 1991). In this presentation, the author discusses assessment rubrics that can be utilized to monitor instructional delivery styles.
http://www.bc.edu/bc_org/avp/cas/comm/free_speech/tinker.html

Instructional Systems Design

Leading scholars in the area of cognitive science and educational methodologies have concluded that it is essential that students need to be taught in a learning environment that enables them to acquire problem-solving skills (McKeachie, 1999). The 21st century workplace does not need employees who have just mastered a particular body of information, instead it prefers to have liberally educated workforce who have mastered written and oral communication skills in addition to acquiring knowledge in their chosen discipline (Saxe, 1988; Senge, 1990; Sims, 1995). Educators should not allow the students to wonder whether they have been learning anything that would actually serve them in the workplace, upon graduation (Barr & Tagg, 1995). It is also important to recognize that state legislatures have introduced demands for outcome assessment (Magill & Herden,1995). In this paper, the authors outline how interactive projects can help the instructor in promoting a learning environment. Furthermore, they also provide initial results of their assessment data. In his 2004 publication, *"Another New Paradigm for Instructional Design"* Reuben Tozman says that a major goal of good instructional design is to marry content with presentation both physically and theoretically (http://www.astd.org/LC/2004/1104_tozman.htm).

According to Reuben Tozman:

- *Instructional systems design (ISD) is the reference used to describe a systematic approach to the design of instruction.*
- *A systematic approach implies a logical application of discovery, testing, and creating solutions.*
- *It also refers to the methodical application of a process each and every time the creation of instruction is required.*

It is well known that Harvard University Professor Howard Gardner suggested that the Intelligence Quotient, IQ alone should not become the primary basis for measuring human

potential. He proposed that there are seven broad areas wherein children and adults can excel and listed them as follows (Armstrong, 1994, Gardner, 2000).

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

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 1980 and 1981). Technology should not be viewed just as a growing trend; rather it must be intelligently implemented as a valuable instructional tool that can accommodate diverse learning styles of 21st century students (Watkins, 2005). It is important to acknowledge that students learn better when alternative modes of information processing are made available at college campuses (Grasha, 1996).

Implementation and Assessment

The author utilizes several tools for assessing the data he has collected over the years. The author tries to implement ideas from several researchers and scholars into practice using modern technology (Marchese, 1991, 1997).

Appendix A shows the five principles that are important while a course is designed, developed and assessed.

Appendix B shows the matrix generated by the author for conducting assessment. In this particular case, the author chose to assess the subject matter of *Industrial Engineering.* The author decided that there were **16** important traits that need to be assessed.

Appendix C documents this data collected using a bar chart. It is desirable to achieve mode values of **5** on all the sixteen characteristics. However this is very unrealistic in an undergraduate environment.

Washington State University's Critical Thinking Rubric has been reproduced here for sake of completeness, in Appendix D.

More details can be found at: http://wsuctproject.wsu.edu/ctr.htm

The procedure followed by the author is also shown Appendix E.

Principles of *Likert Scale* is shown Appendix F.

Conclusions

Referring to the bar chart shown in Appendix C, one can observe that a Likert scale score of **4** has been attained in **6** out of **16** important characteristics or traits that were observed and recorded. This indicates that the students have attained a reasonable level of proficiency in the areas cited.

Furthermore, we can see that a moderate Likert scale score of **3** has been attained in **5** other characteristics. This leads us to the conclusion that the students have gained adequate knowledge in those selected areas. Improvement is needed in these areas and one should strive hard to improve this to record a level of at least **4** on the Likert scale.

Finally, an unacceptable Likert scale score of **2** has been recorded for the remaining **5** characteristics that were observed and recorded. This indicates that the students need to show a lot of improvement in these categories. One should look in to greater detail as to why the performance has been so poor in these areas.

The above analysis shows that students need to be provided more exposure and help in several areas such as systems dynamics, stochastic systems, workspace design etc. There is a need to bring in some *'external experts'* in these areas as guest lecturers in order to provide necessary and appropriate guidance to the students. This will be accomplished when the author is assigned to teach the same class next time.

In conclusion, 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. By choosing different courses and separate characteristics, an instructor can assess any area of engineering technology education using a learning paradigm approach as suggested by the various scholars and researches.

Acknowledgements

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APPENDIX A: The Five Principles

It is quite common for colleges and universities to offer several types of precollege-level courses. These types of courses are basically designed to teach the essential academic skills that are necessary for success in some chosen upper level courses (Brier, 1984). For example, one may suggest that a technical writing course that could help scientists, mathematicians and engineers with their journal publications.

DEFINE: First, the instructor must clearly define the objectives of the course in question. In addition, the instructor should also provide a detailed path for attaining these goals. Such a structure will prepare the students to admire and handle the course with great enthusiasm and creative productivity.

DESIGN: Secondly, the instructor should design *Learning Modules* that can create interest and motivate the student body towards becoming metacognitive learners. In other words, one should be able manage one's own learning. One module should build on the previous module, thereby adding to the knowledge base the students already possess. In other words, students should learn, *"How to Learn."*

DEVELOP: Third, the course should be developed in a systematic manner so that the learner can appreciate the fact that the course is being built on the previous knowledge acquired. For example, knowledge of Physics and Mathematics must be effectively utilized in a *Mechanics* course. It is important to recognize that a methodical approach has always been the principle behind solid fundamental knowledge acquisition.

DEPLOY: Once the first three ideas have been secured in place, it is now necessary to implement them at the required level with appropriate advantage. Here, the instructor should utilize multiples modes of delivery techniques. Such a method has been suggested by Fleming and Mills. Lectures, Reading, Writing, Visual Aids, Tactile and Kinesthetic modes of delivery help to reach students with diverse learning skills.

DECIDE: Finally, there should be an assessment of the course, the curriculum, the learning environment, the student body, and the instructor. It is important to conduct separate assessment of all the above-mentioned five. Once the five sets of data are in placed in their appropriate context, one can judge the impact of problem based learning on the learning environment itself.

Source: Narayanan, Mysore. (2010). *Assessment of Problem Based Learning.* ASEE 117th Annual Conference and Exposition, Louisville, KY. June 24–27, 2007. Paper # AC 2007-18. Session # 1530: Assessment and Evaluation in Engineering Education – I. Monday, 25th June 2007. 2:15 – 4 PM.

APPENDIX B: Matrix Generated for Assessing Industrial Engineering

Likert Scale Score. 5: Excellent. 1: Poor.

TOTAL 16 STUDENTS #	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	MODE
Corporate Planning	4	3	3	3	4	4	4	3	3	3	4	3	4	4	3	3	3
Policy Planning	4	3	5	3	3	4	3	5	3	3	4	3	3	4	3	4	3
Production Control	2	3	2	2	3	4	2	3	2	3	2	3	3	2	2	2	2
Quality Control	4	3	5	5	4	3	3	4	3	4	4	5	3	3	3	4	3
Logistics Development	3	3	5	5	3	3	4	5	4	4	4	5	3	3	3	4	3
Systems Simulation	4	4	5	5	4	4	4	5	4	5	4	5	4	4	4	4	4
Systems Analysis	4	5	5	5	4	4	4	5	5	5	4	5	4	4	4	4	4
System Dynamics	4	2	3	3	4	2	2	3	4	3	4	3	2	2	2	2	2
Stochastic Systems	4	2	2	2	4	4	4	5	2	2	4	2	2	2	2	2	2
Work Space Design	4	4	2	5	4	2	4	2	2	2	4	2	2	4	2	2	2
Time and Motion Study	4	4	5	5	4	3	4	5	4	4	4	4	2	4	4	4	4
Engineering Economics	4	4	5	3	4	3	4	4	4	4	4	5	4	4	4	4	4
Supply Chain Management	4	5	5	5	4	3	4	4	4	4	4	5	4	4	4	4	4
Optimization Techniques	4	3	4	3	4	3	3	3	3	4	4	3	3	3	4	3	3
Operations Research	4	2	4	2	4	2	4	2	2	4	2	2	4	2	2	4	2
Human Factors	4	4	5	4	4	3	4	4	3	4	4	5	4	4	4	4	4

Sample Size: 16 Students.

Subject Studied: *Industrial Engineering.* Certain selected topics.

Methodology: Assessment of a comprehensive *Learner-Centered Portfolio* generated by the students.

Assessment: Assessment data collected by Mysore Narayanan. Assessment is based on *Likert Scale.* Please see Appendix **F** for details.

Analysis of the Bar Chart

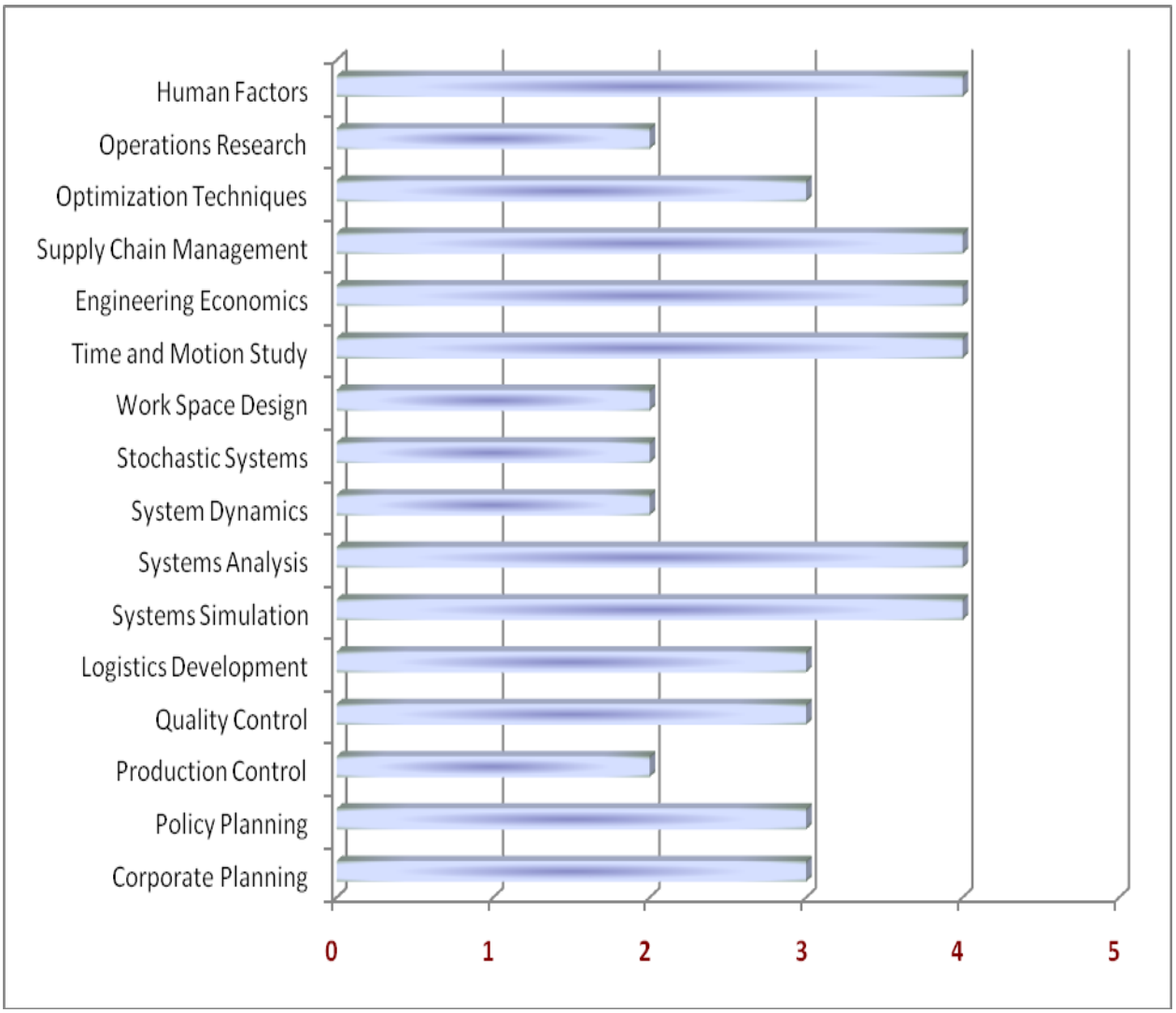
Likert Scale score of 5: None of the **16** characteristics chosen secured this maximum possible score of **5.** This indicates there is much work to be carried out. Efforts should be concentrated on areas where one can accomplish this level of achievement.

Likert Scale score of 4: Six out of the **16** characteristics chosen secured this acceptable level score of **4.** This indicates that the students have a good understanding of the topics involved. However, one should strive hard to improve some of these to the maximum possible level of **5.**

Likert Scale score of 3: Five other characteristics out of the **16** characteristics chosen secured this moderate level score of **3.** This indicates that the students are trying to grasp the material, however, they have difficulty in comprehension. One should concentrate on improving this to a level of **4** at least.

Likert Scale score of 2: The remaining five out of the **16** characteristics chosen secured an unacceptable level score of **2.** This indicates the students have great difficulty in understanding these topics.

APPENDIX C: Likert Scale Bar Chart for Conducting Assessment



LIKERT SCALE SCORE

Strongly Agree or Excellent	**5**
Agree or Good	**4**
Remain Undecided or Average	**3**
Disagree or Needs improvement	**2**
Strongly Disagree or Unacceptable	**1**

APPENDIX D: W.S.U. CRITICAL THINKING RUBRIC

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

1. **Identifies, summarizes (and appropriately reformulates) the problem/question/work assignment.**

This dimension focuses on task or issue identification, including subsidiary, embedded, or implicit aspects of an issue and the relationships integral to effective analysis.

2. **Identifies and considers the influence of context and assumptions.**

This dimension focuses on scope and context, and considers audience of the analysis. Context includes recognition of the relative nature of context and assumptions, the reflective challenges in addressing this complexity and bias, including the way ethics are shaped by context and shape assumptions

3. **Develops, and communicates OWN perspective, hypothesis or position.**

This dimension focuses on ownership of an issue, indicated by the justification and advancement of an original view or hypothesis, recognition of own bias, and skill at qualifying or integrating contrary views or interpretations.

4. **Presents, assesses, and analyzes appropriate supporting data/evidence.**

This dimension focuses on evidence of search, selection, and source evaluation skills--including accuracy, relevance and completeness. High scores provide evidence of bias recognition, causality, and effective organization.

5. **Integrates issue using OTHER (disciplinary) perspectives and positions.**

This dimension focuses on the treatment of diverse perspectives, effective interpretation and integration of contrary views and evidence through the reflective and nuanced judgment and justification.

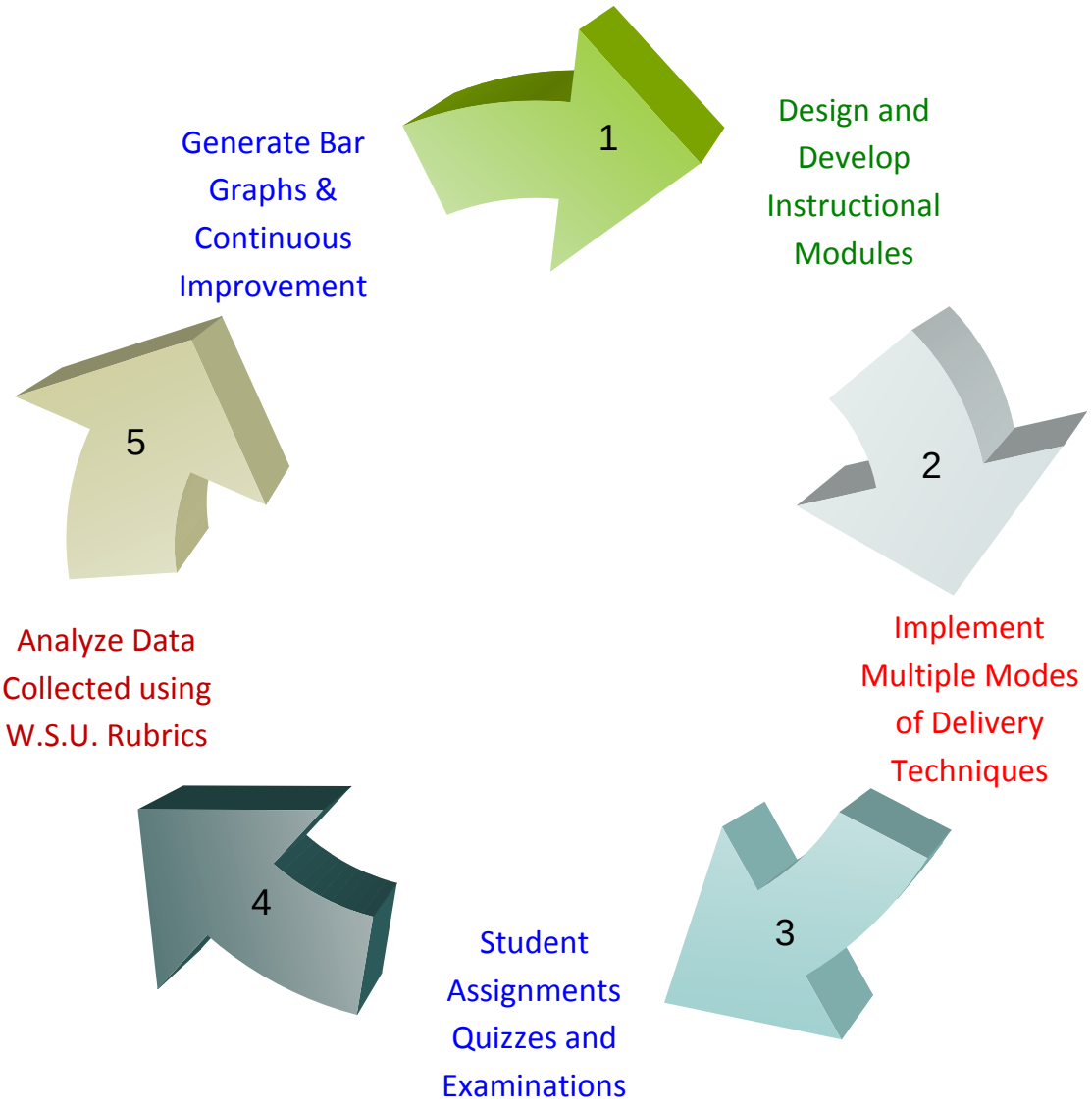
6. **Identifies and assesses conclusions, implications, and consequences.**

This dimension focuses on integrating previous dimensions and extending them as they explicitly and implicitly resolve in consequences. Well developed conclusions do more than summarize. They establish new directions for consideration in light of context and the breadth and depth of the evidence.

7. **Communicates effectively.**

This dimension focuses on the presentation. If written, it is organized effectively, cited correctly; the language use is clear and effective, errors are minimal, and the style and format are appropriate for the audience.

APPENDIX E: Methodology used by the author.



The author has previously used this approach in other research and other ASEE publications

APPENDIX F: Likert Scale

Rensis Likert, the American educator and organizational psychologist was the founder of *University of Michigan's Institute for Social Research.* Likert is best known for his research on management styles, development of Likert Scales and the Linking pin model (Likert, 1932). Just like W. Edwards Deming, Likert's books on theory of management were very popular in postwar Japan during the sixties and seventies.

A Likert scale is often used in research surveys and questionnaires.

Likert scale is a type of psychometric response scale.

Likert Scale is perhaps the most widely used instrument in sociology research.

Likert scaling is referred to as a bipolar scaling method.

Presented with a statement, Likert scale attempts to measure and record either the positive or the negative response provided.

While addressing and responding to a statement presented on a Likert scale questionnaire, respondents indicate whether they

Strongly Agree (**5**),

Agree (**4**),

Remain Undecided (**3**),

Disagree (**2**)

Strongly Disagree (**1**).

It is important to emphasize the fact that these responses, **5 – 4 – 3 – 2 – 1**

represent what is known as *ordinal level of measurement.*

This is much different from other scales such as *ratio scale* or *interval scale.*

The Likert Scale represents a built-in, inherent order or sequence. For example:

Strongly Agree to Strongly Disagree.

Biggest to Smallest.

Maximum to Least.

Strongest to Weakest.

Tallest to Shortest.

Heaviest to Lightest.

Largest to Smallest.

Etc.

Numbers (**1** to **5**) are assigned to the responses received, however these numbers do not indicate the magnitude of difference between the responses. One may recall that in case of ratio scale or interval scale the magnitude of difference, indeed has a specific meaning attached to it.

The data is not continuous. Therefore it must be interpreted carefully. It is not appropriate to generate or create a histogram using the data collected. Mean (average) values do not have any meaning for interpretation. Furthermore *standard deviation* does not convey anything. Therefore, the data are normally summarized using a median or mode. The author prefers to use *mode.*

Source:

1. Likert Rensis (2004). *Evaluation Cookbook,* Learning Technology Dissemination Initiative, Heriot – Watt University, Riccarton, Edinburgh, EH14 4AS, Scotland.

2. Likert, R. (1932). *A Technique for the Measurement of Attitudes.* Archives of Psychology 140, 55.

3. www.icbl.hw.ac.uk/ltdi/**cookbook**/info_**likert_scale**/printable.pdf

References:

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

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

3. Barr, R. B., & Tagg, J. (1995, November/December). *From teaching to learning: A new paradigm for undergraduate education*. Change: The Magazine of Higher Education, 13-24.

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

5. Dunn, R., & Dunn, K (1978). *Teaching students through their individual learning styles.* Reston, VA: Reston Publishing Company, Inc.

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

7. Gardner, Howard (1993). *Frames of mind: The Theory of Multiple Intelligences (10th anniversary edition).* New York: Basic Books.

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

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

10. Gregorc, A. F., & Ward, H. B. (1997). *Implications for learning and teaching:* A new definition for individual. NASSP Bulletin, 61, 20-26.

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

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

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

14. Magill, S. L., & Herden, R. P. (1998, October). *Using educational outcomes and student portfolios to steer management education.* Journal of Management Education, 22 (5), 567-90.

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

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

17. McKeachie, W.J. (1999). *Teaching Tips: Strategies, Research, and Theory for College and University Teachers.* Boston: Houghton Mifflin Company.

18. Narayanan, Mysore. (2007). *Assessment of Ethics Modules in an Engineering Curriculum.* ASEE 114th Annual Conference and Exposition, Honolulu, HI. June 24–27, 2007. Paper # AC 2007-14. Teaching Ethics – II. Session # 3440. Wednesday, 27th June 2007. 12:30 – 2 PM.

19. Narayanan, Mysore. (2007). *Assessment of Perceptual Modality Styles.* ASEE 114th Annual Conference and Exposition, Honolulu, HI. June 24–27, 2007. Paper # AC 2007-18. Assessment and Evaluation in Engineering Education – I. Session # 1530. Monday, 25th June 2007. 2:15 – 4 PM.

20. Narayanan, Mysore (2008). *Assessment of Water Conservation Education.* Proceedings of World Environmental and Water Resources Congress 2008, May 12- 16, 2008. Honolulu, Hawaii. (ASCE.)

21. Saxe, S. (1990, June). *Peer influence and learning.* Training and Development Journal, 42 (6), 50-53.

22. Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization.* New York: Currency Doubleday.

23. Sims, R. R. (1992, Fall). Developing the learning climate in public sector training programs. *Public Personnel Management,* 21 (3), 335-346

24. Young, C. O., Sr., & Young, L. H. (1999). *Assessing learning in interactive courses.* Journal on Excellence in College Teaching, 10 (1), 63-76.

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

Additional Resources:

1. http://wsuctproject.wsu.edu/ctr.htm
2. http://www.pz.harvard.edu/PIs/HG.htm
3. http://www.icbl.hw.ac.uk/ltdi/cookbook/info_likert_scale/
4. http://www.bc.edu/bc_org/avp/cas/comm/free_speech/tinker.html