AC 2009-1290: UNDERSTANDING COGNITIVE STYLE AND LEARNING STYLE AND THEIR APPLICATION TO TEACHING AND LEARNING IN ENGINEERING.

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Understanding Cognitive Style and Learning Style and Their Application to Teaching and Learning in Engineering

Key Words: Cognitive Style, Learning Style, PowerPoint

Abstract

A general perception exists that visually-oriented teaching, using PowerPoint, is the most effective approach to use in engineering education. However, in a survey completed last year by about 200 engineering students, the majority of the students indicated that they preferred board-written lectures to lectures using PowerPoint presentations for technical material. To remedy the possible problem with cognitive load, a new set of PowerPoint slides were developed, in which all parts of figures and equations sequentially appear. Students in two different mechanical engineering courses were surveyed using the VARK (Visual, Aural, Read/Write, Kinesthetic) questionnaire to classify students' learning style and to determine their attitude towards PowerPoint lectures. The majority of students surveyed were found to be kinesthetic or read-write in their learning style. Those students who had experienced the animated PowerPoint presentations were much more favorable towards PowerPoint than those who had not. Future work will compare VARK learning styles of engineering students with those of liberal arts students and enhanced PowerPoint lectures with PowerPoint that includes printed handouts.

Introduction

In order to succeed in engineering studies, students must possess certain cognitive traits:
- The ability to handle higher mathematics
- The ability to identify and formulate problems
- The ability to model physical situations with mathematical models
- The ability to relate the mathematical solutions to physical solutions
- The ability to be creative in generating alternative solutions

In addition, each student will have a certain characteristic learning style which will influence the type of presentation or activity that best communicates concepts to him or her. There is a general perception that visually-oriented teaching, using Power Point, is the most effective approach to use in engineering education. However, in a survey completed last year by about 200 engineering students, the majority of the students indicated that they preferred board-written lectures to lectures using Power Point presentations for technical material. The survey result provokes a need to clarify the distinctive characteristics our students in regard to teaching and learning in engineering education.

After initial attempts to understand how students were learning, the engineering faculty authors teamed up with a psychology professor, an expert in educational psychology (V.S.) who provided significant insights into what we were observing.
For example, one probable aspect of students' dissatisfaction with PowerPoint for technical presentations is the limitation of short-term memory in connecting previous slides of data and equations with a present slide, a problem that doesn't arise when blackboards are covered with equations and schematics (before they are erased).

PowerPoint Dissatisfaction and the Issue of Cognitive Load

In a survey which was completed and reported on last year, it was noted that our engineering students for the most part, did not favor PowerPoint lectures for technical material. They preferred traditional board work instead.[1] The authors are now beginning to understand that this preference may actually be related to the concept of "cognitive loading." Cognitive loading refers to the maximum amount of information that can be stored in short-term memory. In dealing with a lecture or presentation that involves multiple equations, the mind can only recall so many "bits" from a previous slide. Being able to glance back at previous work, or to see an entire design or proof on a board, is often critical in understanding new technical material.

As Chandler and Sweller explained, "Cognitive load theory suggests that effective instructional material facilitates learning by directing cognitive resources toward activities that are relevant to learning rather than toward preliminaries to learning. One example of ineffective instruction occurs if learners unnecessarily are required to mentally integrate disparate sources of mutually referring information such as separate text and diagrams. Such split-source information may generate a heavy cognitive load, because material must be mentally integrated before learning can commence."[2]

In an effort to improve the cognitive load issue, one of the authors has begun developing PowerPoint presentations using animated figure and equation slides. Figure 1 shows an example.

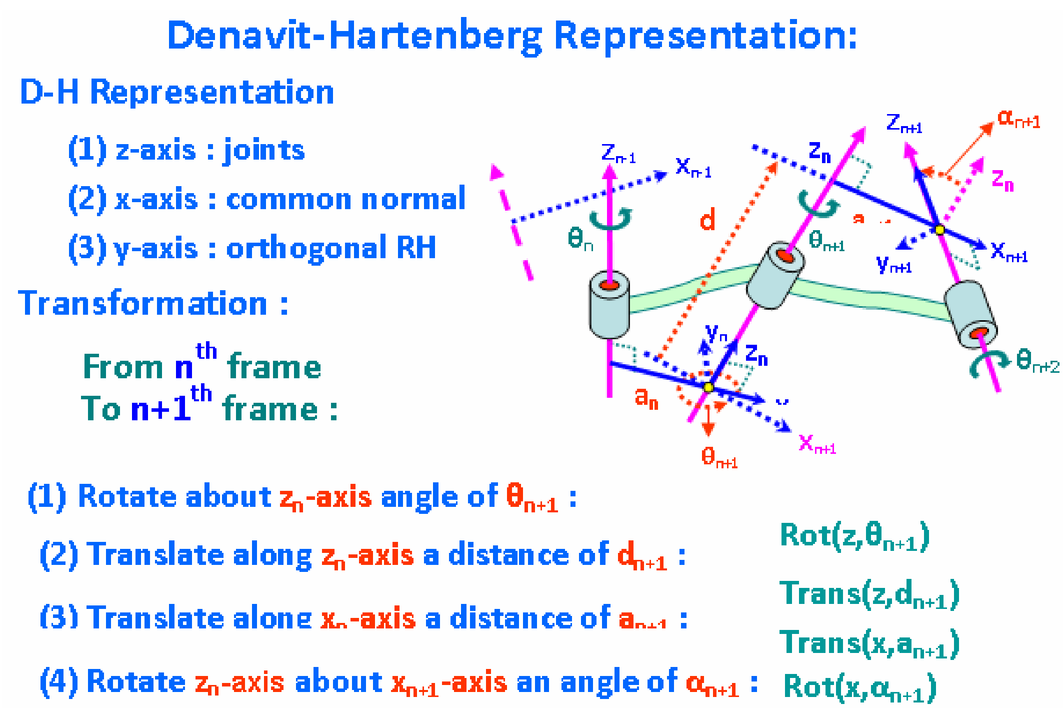


Figure 1. An example of a whole frame for PowerPoint

Each part of an equation or a figure appears sequentially. A single slide, used in a course such as Kinematics, may contain 20 to 100 individual pieces, each of which appears at the proper time in the slide. Appendix 2 presents an example of one complete figure. Since the entire file of PowerPoint presentations cannot be inserted in this file, the figure shows only a small part of one animated frame. The development process is very time-consuming, but students appreciate the effort, and learning is improving.

Cognitive Style

One goal of the authors was to link cognitive or learning style of our students to their preference for a certain lecture format, particularly PowerPoint presentations. While learning different concepts, people sometimes take different approaches. For example, some people like to learn while paying attention to the instructor and taking notes and studying theory, whereas others prefer to study by themselves, do practice or prefer to work within groups. Some respond strongly to visual forms of information; others get more from verbal forms. Some prefer to learn actively and interactively, and others function more introspectively and individually. Accordingly, the relationship between teaching and learning is an important factor for improving educational performance. To increase a student's success in engineering education, one must understand that student's individual learning style and provide instructional methods and environments accordingly

Cognitive style historically has referred to a psychological dimension representing consistencies in an individual's manner of cognitive functioning, particularly with respect to acquiring and processing information. The development of cognitive style research is an interesting topic in the history of psychology. At the present time, many would agree that research on cognitive styles has reached an impasse. The paradox of the current situation is that interest in building a coherent theory of cognitive styles remains at a low level among researchers in the cognitive sciences. However, researchers in applied fields have found that cognitive style can be a better predictor of an individual's success in a particular situation than general intelligence or situational factors.

Basic research on cognitive styles peaked between the late 1940s and early 1970s. During this time, the term cognitive style was more commonly used. This line of research focused on examining individual differences operating at basic or early stages of information processing, including perception, concept formation, sorting, and categorization. [3] The notion of cognitive style was introduced by Klein and Schlesinger[4] and Klein[5], who were interested in possible relations between individual differences in perception and personality. Klein was the first to consider cognitive styles as patterns of adaption to the external world that regulate an individual's cognitive functioning.

Along with field dependence-independence[6] and leveling-sharpening, dozens of other style dimensions were proposed. Messick[7] attempted to organize these numerous dimensions and proposed a list of 19 cognitive styles; Keefe[8] synthesized a list of 40 separate styles. Despite the numerous proposed cognitive style dimensions, no attempt was made to integrate them. This approach led to a situation in which as many different cognitive styles were described as there were researchers who could design different tasks. Most studies of cognitive styles were descriptive, did not attempt to elucidate the underlying nature of the construct or relate styles to information processing theories, and were designed according to the assumption that styles are limited to only very basic information processing operations. The main message of the research is that styles represent relatively stable individual differences in preferred ways of organizing and processing information that cut across the personality and cognitive characteristics of an individual.

Despite declining interest in styles among cognitive scientists by the end of the 1970s, the number of publications on styles in applied fields increased rapidly, reflecting the practical necessity of understanding individual differences in mechanisms of cognitive functioning. The main feature of these studies has been their focus on styles related to complex cognitive tasks, such as problem solving, decision making, learning, and individuals' causal explanations of life events. This is in contrast to basic research on cognitive styles, which focused primarily on individual differences in perception and basic cognitive functions.

The field that has generated the largest number of applied studies on cognitive styles is education. In education, research has aimed at understanding individual differences in learning processes, called learning styles. One distinguishing contribution of these studies is the use of the self-report questionnaire as a method of style assessment, reflecting a new tendency in cognitive style research to study conscious preferences in organizing and processing information[3]. Another significant contribution of these studies is the examination of external factors that affect the formation of an individual's style. These studies converged on the conclusion that cognitive styles, although relatively stable, are malleable, can be adapted to changing environmental and situational demands, and can be modified by life experiences.

Is it cognitive style or learning style? Part of the attempt to clarify style theory and make better use of it in professional practice must involve resolving a definition of learning style.[9] The organization of style theory into a three-nested model forming an analogous 'onion,' devised by Curry[10] represents a particularly useful effort at relating models in both the cognition- and learning-centered traditions. Curry suggested that an inner core of a 'style onion' is made up of personality-centered models, leading to a second strata of information-processing models, and then to an outer layer of instructional-preference models of learning style.

Many studies have been done that attempt to bridge the cognitive styles/learning styles/personality styles literature and the field of engineering:

Using a Kolb approach to cognitive styles, Calgitay [11] found that assimilators and covergers performed better than divergers and accommodators.
Eder and Hubka [12] presented various learning styles as one element in their model of design education as a transformational process taking a student from an input state to an output state. Each student has a unique combination of knowledge, skills, attitudes, values, and learning style.
Hativa and Birenbaum [13] noted that students preferred "clear, organized, and interesting lectures," and disliked pure "information transmission."
Holvikivi [14] concluded that analysis of student learning styles can be problematic and does not necessarily enhance engineering education.

Mastor and Ismail [15] attempted to differentiate engineering and information technology students using the NEO Personality Inventory-Revised along with the Group Embedded Field Test and found that engineers are likely to be classified as “field-independent learners.” Zimmerman et. al. [16] applied the Myers Briggs Type Indicator and the Group Enhanced Field Test, concluding that their students preferred the field-independent learning style.

Each study has used different inventories to measure cognitive styles, learning styles, and/or personality styles. In engineering education, these studies have attempted to relate style to learning outcomes in order to make engineering education more effective. The results show that learning style theory is a potential tool for guiding the design and improvement of courses and helping students to improve their individual performance. [17]

The survey

In order to understand the students’ learning styles and their reactions to the two main lecture methods, a survey was conducted with two different groups of mechanical engineering students. The desire was to answer the following questions:

1. What is actually the main learning style of our mechanical engineering students?
2. Does learning style affect the students’ preference for PowerPoint Presentations?
3. Is the modified (animated) PowerPoint preferred by students who have experienced it?

The main lecture methods considered were the typical board writing approach and the PowerPoint presentation. However, the new PowerPoint presentations were specifically designed for engineering classes with figures animated progressively and equations presented step-by-step.

The first group, called “**Group One**” was drawn from an engineering class of 17 students (juniors and seniors) who had not experienced the progressive PowerPoint presentation and the second group, called “**Group Two**” was drawn from an engineering class of 50 students (mostly juniors) who had experienced the progressive presentation of the PowerPoint in their classes.

The survey included 20 questions. The first 16 questions were used from the VARK(Visual, Aural, Read/Write, Kinesthetic) questionnaire to classify students’ learning styles, and the last four questions were given to view the correlation of the students’ learning styles to the different teaching styles.

The study used the VARK questionnaire[18] as a measure of learning style. The acronym VARK stands for Visual, Aural, Read/write, and Kinesthetic sensory modalities that are used for learning information. Fleming and Mills[19] suggested four categories that seemed to reflect the experiences of their students. The Visual preference includes the depiction of information in charts, graphs, flow charts, and all the symbolic arrows, circles, hierarchies and other devices that instructors use to represent what could have been presented in words. The Auditory perceptual mode describes a preference for information that is "heard." Students with this modality report that they learn best from lectures, tutorials, tapes, group discussion, speaking, web chat, talking things through. The Read/write preference is for information displayed as words. Not surprisingly, many academics have a strong preference for this modality. This preference emphasizes text-based input and output — reading and writing in all its forms. The Kinesthetic modality refers to the "perceptual preference related to the use of experience and practice (simulated or real)." Although such an experience may invoke other modalities, the key is that the student is connected to reality, "either through experience, example, practice or simulation."

In the survey, VARK analysis was chosen instead of a Kolb or Felder-Silverman instrument for a number of reasons:

- It is available without cost
- It is easily transcribed to a paper instrument
- It can be scored directly without logging online.

There is not any research that has been published yet on the psychometric properties of the VARK instrument. However, VARK has been used as a useful teaching tool as Dr. Mrilla Svinicki at University of Texas at Austin stated, “If you are using it as a teaching instrument, it is more than satisfactory for that use and it has excellent instructional materials to support it.”[18]

Survey Results

Learning Styles

Figure 1-1 represents the number of students classified in the four learning styles according to VARK analysis, aural, kinesthetic, Read/Write and visual. Figure 1-2 and figure 1-3 represent the students’ learning styles by groups in numbers and in percentages, respectively.

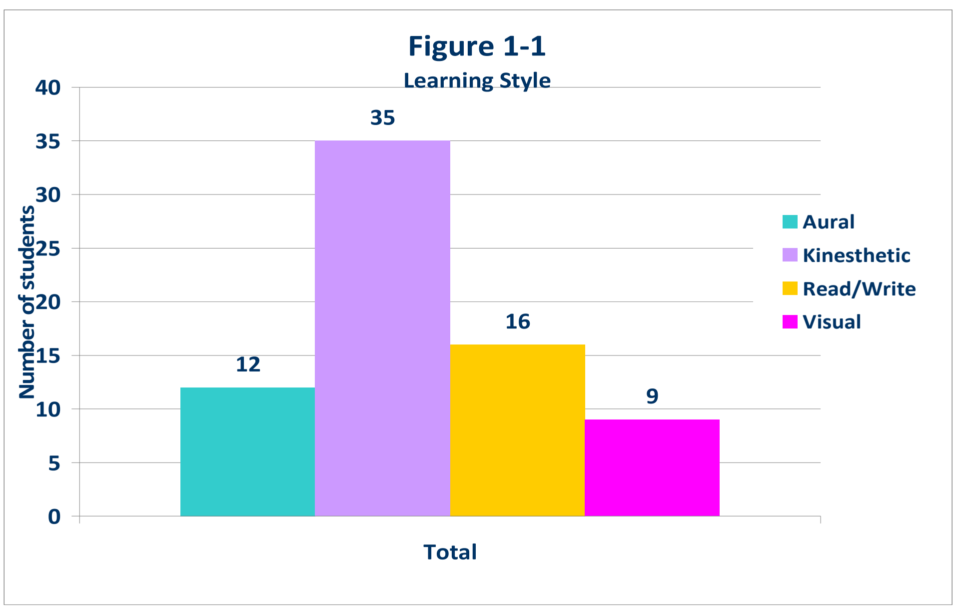


Figure 1-1. Learning Style

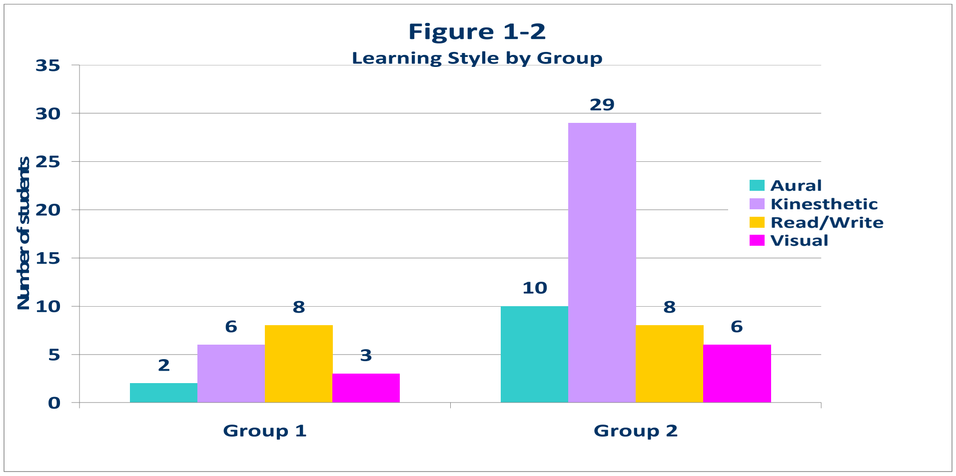


Figure 1-2. Learning Style by Group

It is interesting to know that 49 % students combined are kinesthetic, while read/write 22 %, aural 17 % and visual only 12 %. This means that majority of students may be inclined to learn better by doing than by watching and listening. This tendency may require more study to understand the corelation of the kinethetically oriented students and their preference in majoring engineering fields.

Self-identifying

Figure 2-1 represents the students' self identifying their learning styles and the results from VARK analysis. In survey question 17, there were only three learning styles that students could choose. The majority of students who are in the kinesthetic group classified themselves as visual. This may be because they had no choice for kinesthetic from the questionnaire. In the aural and read/write groups, students' responses are more diverse than for the group of visual. The comparison between the self-identification and the VARK results is the subject of further study.

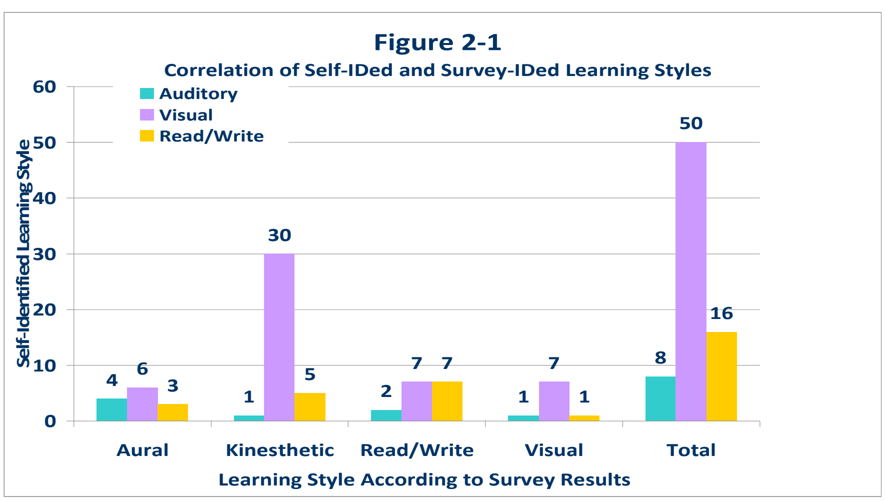


Figure 2-1. Learning Style by Identified by Students

PowerPoint vs. board-writing: in total

Figure 3-1 and figure 3-2 represent the students' preference between the PowerPoint presentation style approach and the board-writing approach classified by their learning styles in numbers and in percentage, respectively.

More than half of the students do not have confidence that the PowerPoint is a good tool for engineering classes.

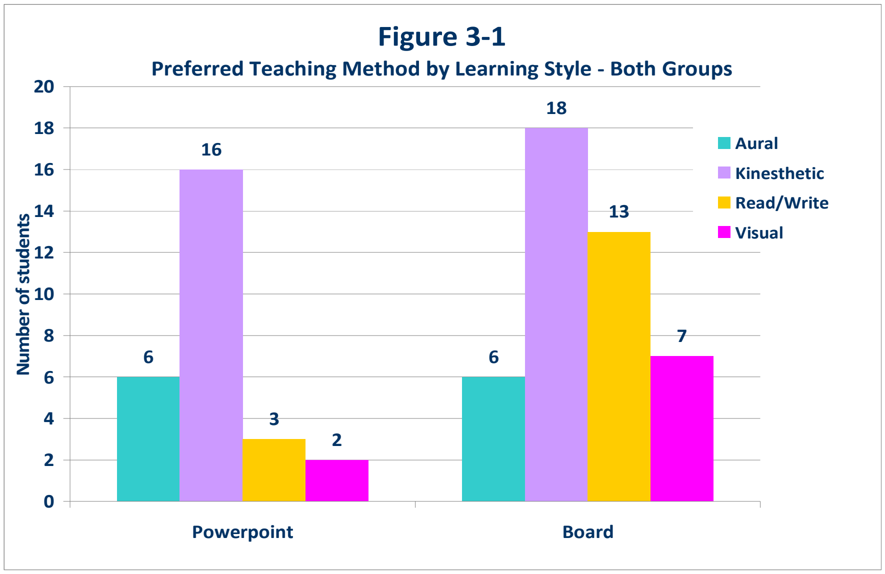


Figure 3-1. Preferred Learning Style in Numbers

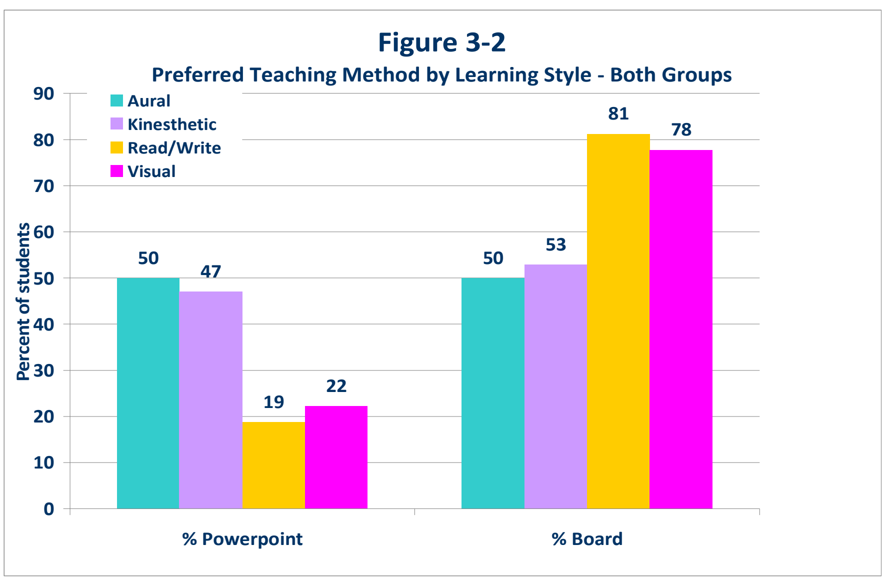


Figure 3-2. Preferred Learning Style in Percentage

PowerPoint vs. board-writing: in Group One

Figure 4-1 and figure 4-2 represent the preference of students of Group Two for two teaching methods in numbers and in percentages respectively.

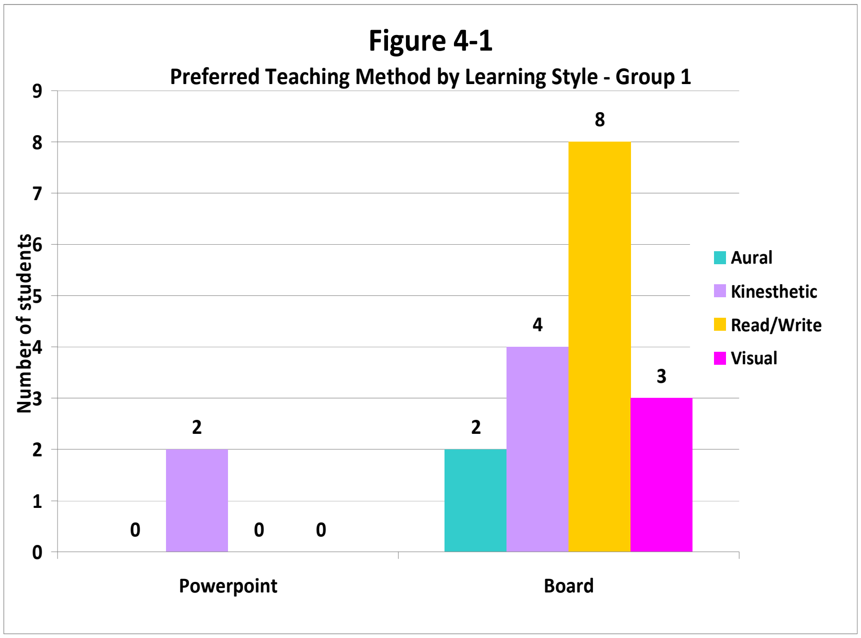


Figure 4-1. Preferred Learning Style in Numbers – Group 1

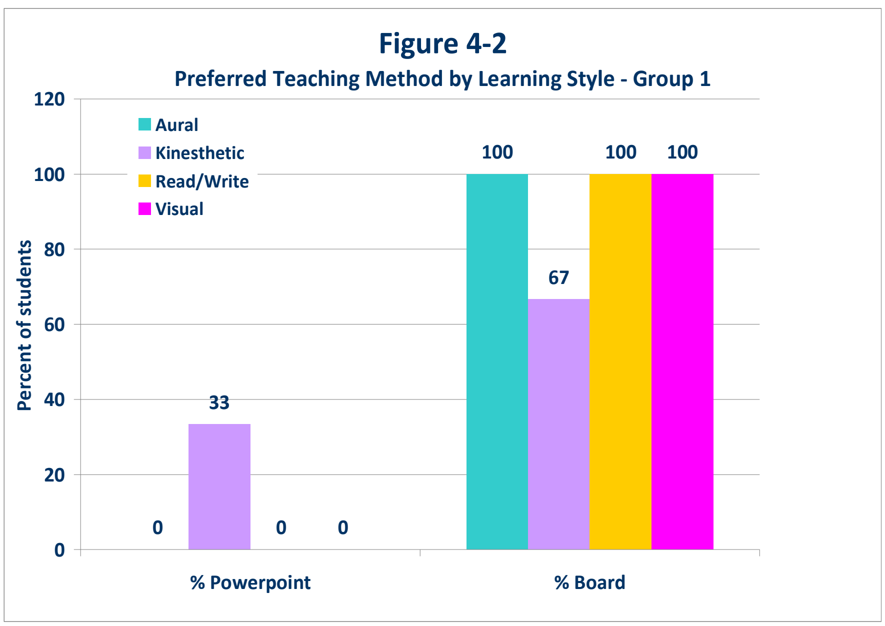


Figure 4-2. Preferred Learning Style in Percentage – Group 1

Figure 4-3 represent the students' preference according to their learning styles. Only kinesthetically oriented students prefered the Powerpoint.

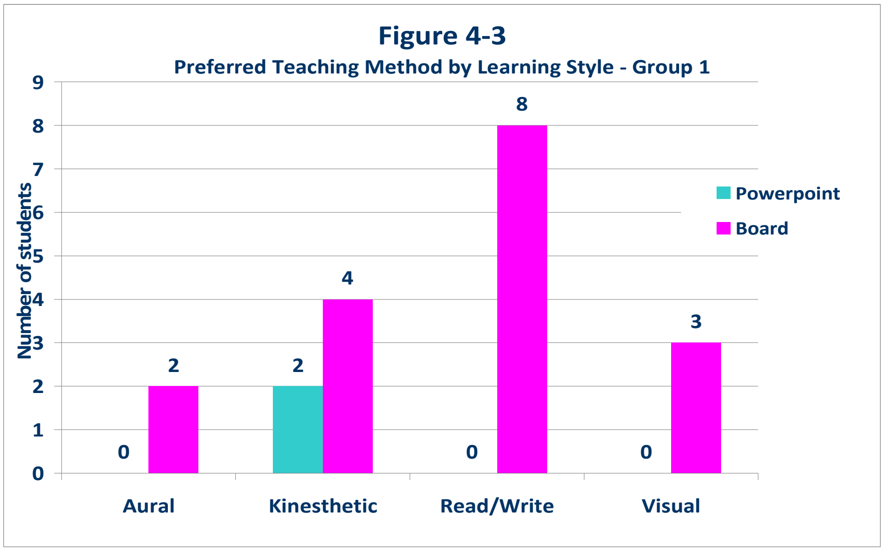


Figure 4-3. Preferred Learning Style by Learning Styles – Group 1

PowerPoint vs. board-writing: in Group Two

Figure 5-1 and figure 5-2 represent the preference of students of Group Two of two teaching methods in numbers and in percentages, respectively. The majority of the students prefer the board-writing approach. However, more students from this group chose the PowerPoint approach than Group One. The main reason is because the students from this group have experienced the progressively presented PowerPoint in their classes.

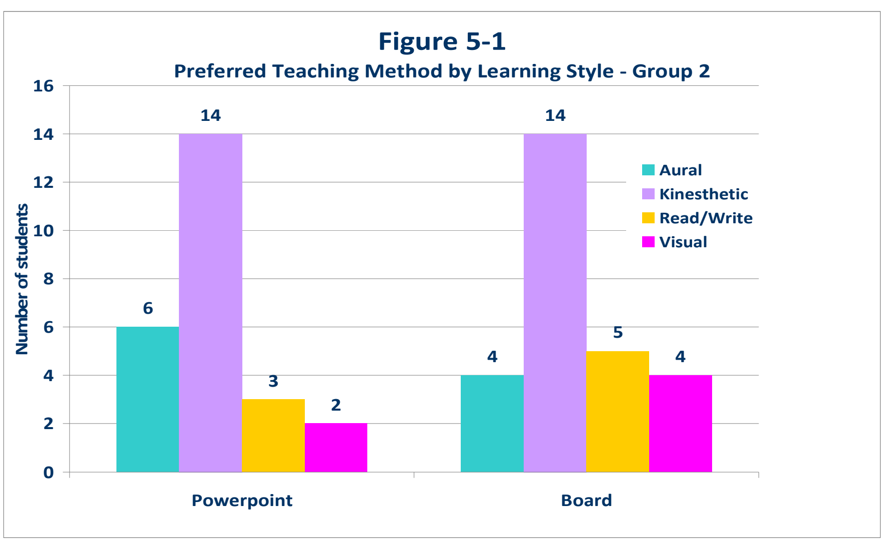


Figure 5-1. Preferred Learning Style in Numbers – Group 2

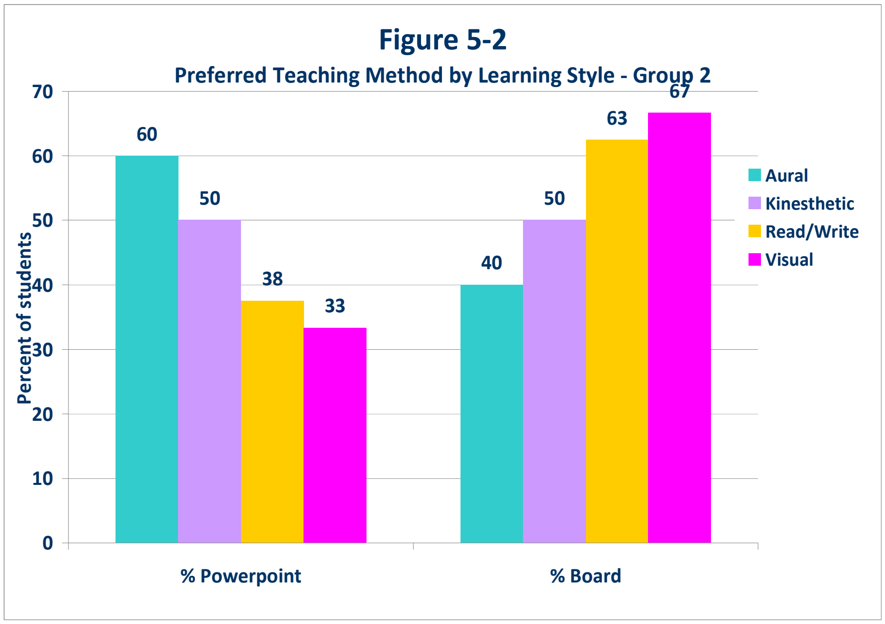


Figure 5-2. Preferred Learning Style in Percentage – Group 2

In figure 5-3, all students who are aural, read/write, and visual do not have any preference to the Powerpoint approach.

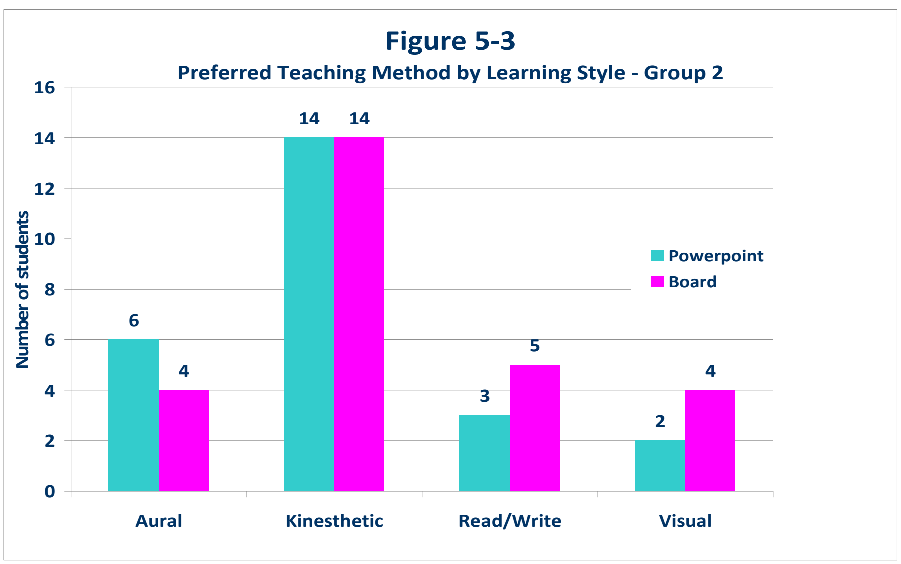


Figure 5-3. Preferred Learning Style by Learning Styles – Group 2

One difference between Group One and Group Two is that students of Group Two had a more positive response to the Powerpoint apprroach. The cause for the difference can be derived easily from the fact that students of Group Two had experienced the Powerpoint approach, which had been carfully prepared for engineering classes.

Group One vs. Group Two

Figure 6-1 and figure 6-2 represent the comparison between the two groups according to their preference from the two groups, in numbers and in percentages, respectively. The difference in their preference between the two groups is obvious: group two has more students who like the Powerpoint than group one. Since students from group two have experienced the progressively prepared Powerpoint presentation, they evidently had this response. This difference indicates that when the Powerpoint is well and properly prepared for engineering classes, it can be a useful tool in engineering classes.

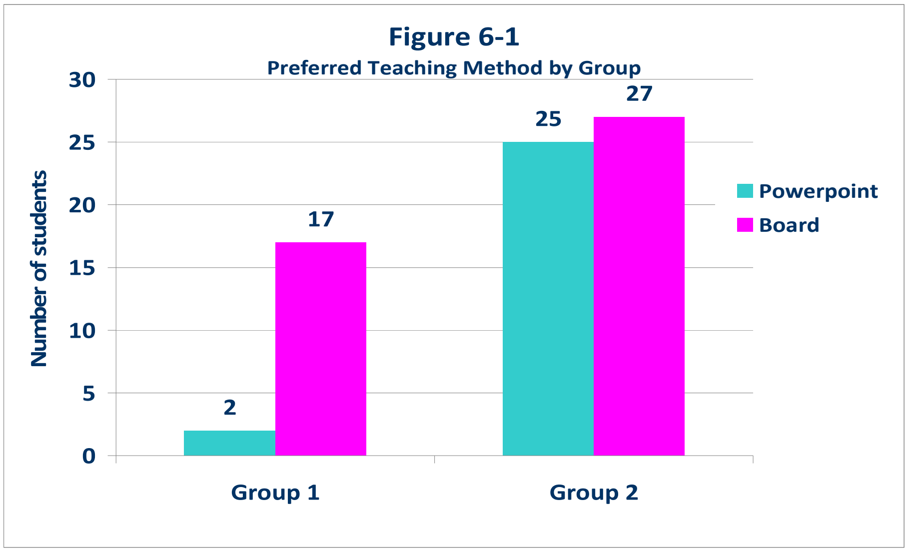


Figure 6-1. Preferred Learning Style in Numbers – Both Groups

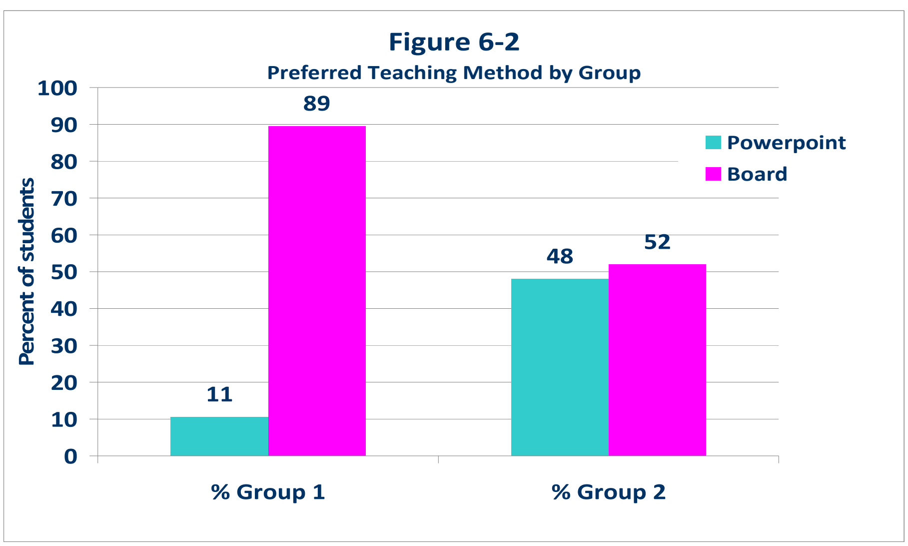


Figure 6-2. Preferred Learning Style in Numbers – Both Groups

Particularly PowerPoint

In survey question 20, students were asked to choose their level of preference to PowerPoint. Figure 7-1 and figure 7-2 represent the students' response to the PowerPoint approach for both groups, combined in numbers and in percentages, respectively.

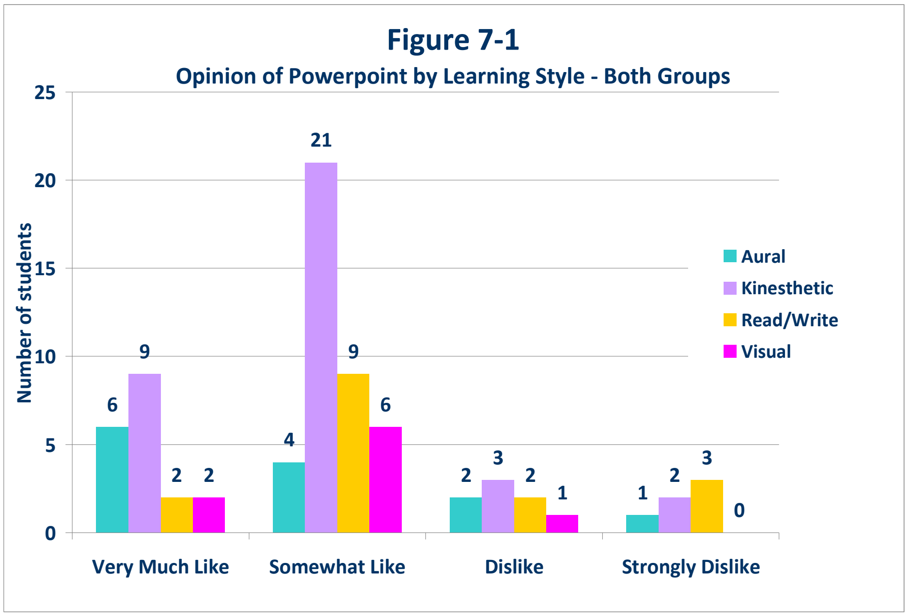


Figure 7-1. Opinion of PowerPoint in Numbers – Both Groups

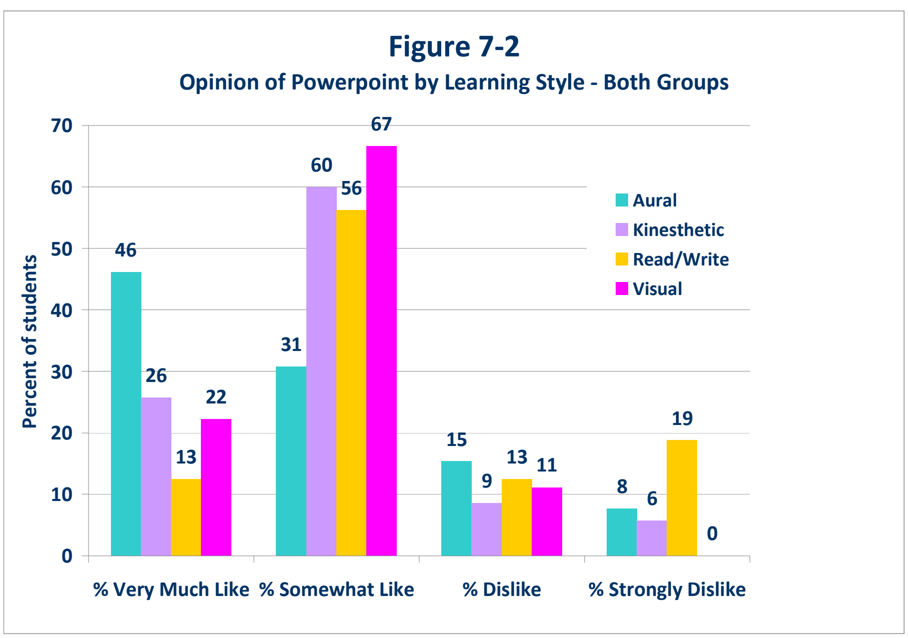


Figure 7-2. Opinion of PowerPoint in Percentage – Both Groups

Even more than half of the students preferred the board writing approach; most students had positive responses to the PowerPoint approach. Figure 7-3 represents this tendency well. However, more than 20 % of the students dislike or strongly dislike the PowerPoint approach.

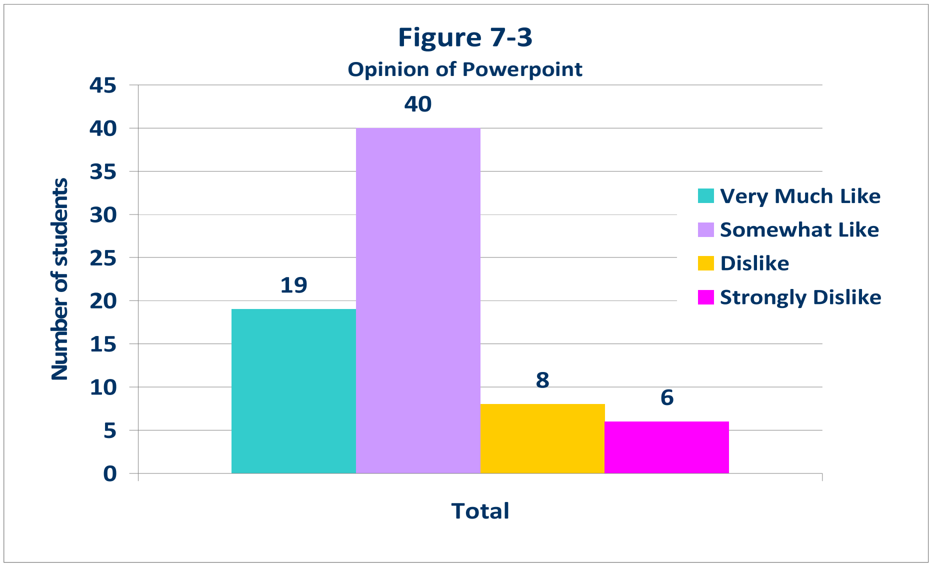


Figure 7-3. Opinion of PowerPoint in Numbers – Combined

This tendency deviates between the two groups, however. Figure 7-4 and figure 7-5 represent the students' response to the survey question 20, separate into two groups in numbers and in percentages, respectively.

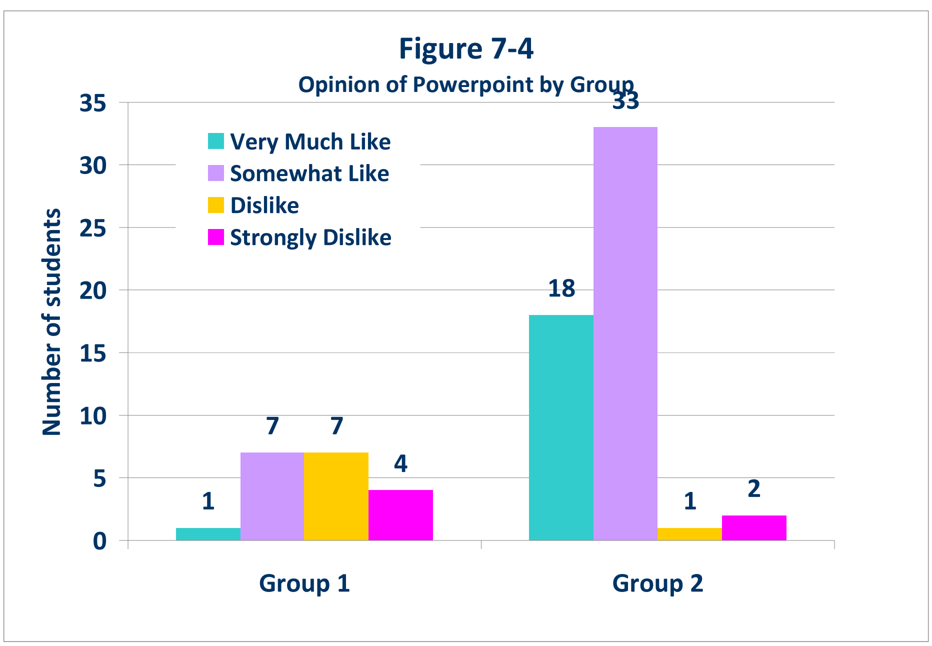


Figure 7-4. Opinion of PowerPoint in Numbers – by Groups

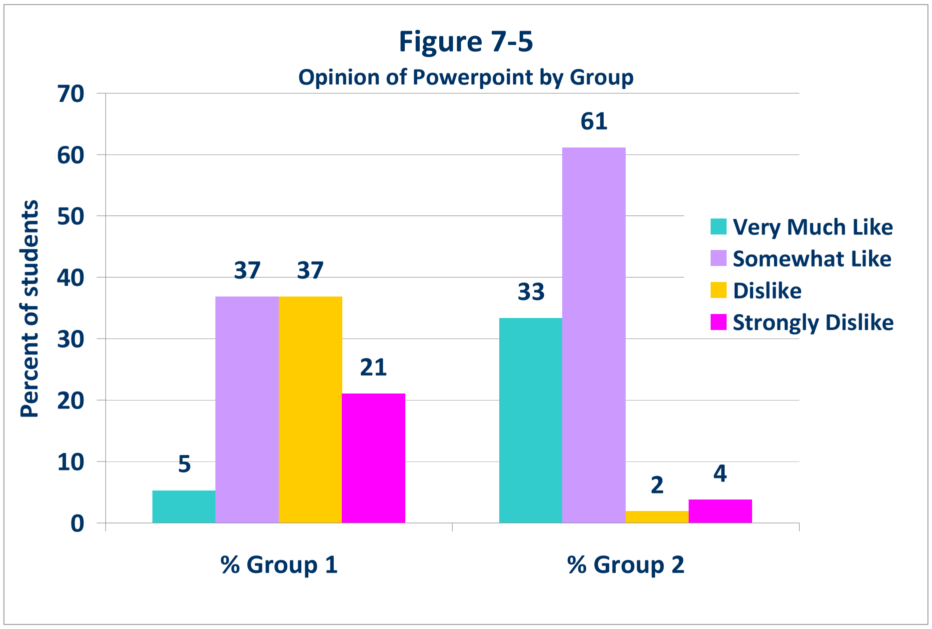


Figure 7-5. Opinion of PowerPoint in Percentage – by Groups

In Group One, more than half of the students expressed that they do not like the PowerPoint approach and even 21 % of the students strongly dislike it. Furthermore, students from Group Two like the PowerPoint approach, only 4 % students "strongly dislike" the PowerPoint approach, and only 2 % "dislike" it. The 33 % of students like the PowerPoint approach "very much" and 61 % "somewhat" like it.

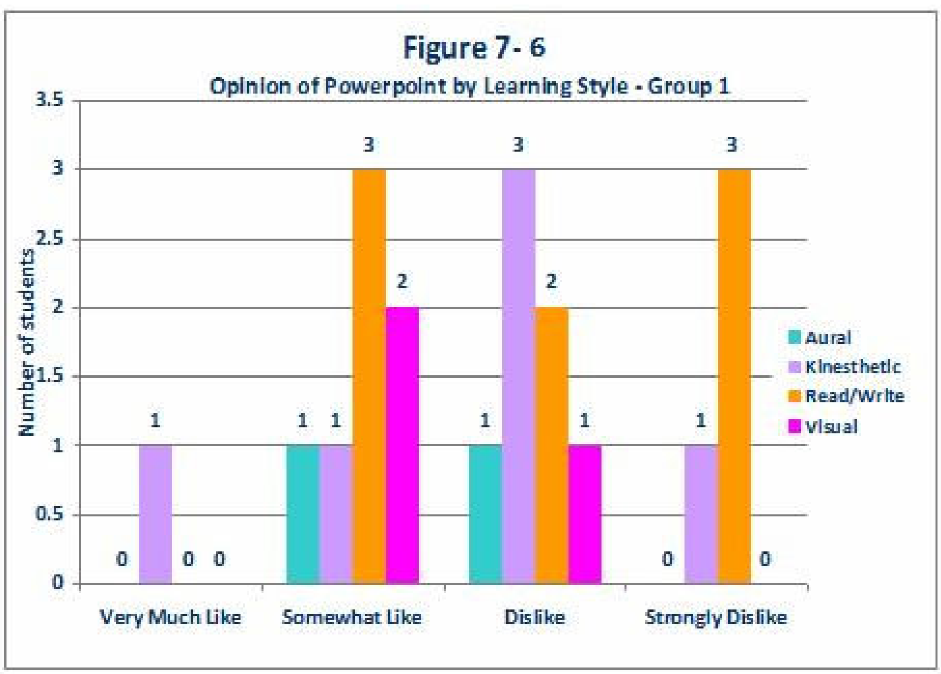


Figure 7-6. Opinion of PowerPoint by Learning Styles –Group 1

Figure 7-6 represents the students' response to the PowerPoint approach by their learning styles. In Group One, visually oriented students like the PowerPoint approach and aurally oriented students are divided in by their reactions by half.

However, this tendency is drastically changed in Group Two. Only two students "strongly dislike" the PowerPoint approach while most students like it "very much" or "somewhat like" it. Figure 7-7 shows this tendency in numbers. It is obvious that the students who experienced the progressively prepared PowerPoint, most students welcome it. This becomes the reason for the further development of this style of PowerPoint as a better teaching tool.

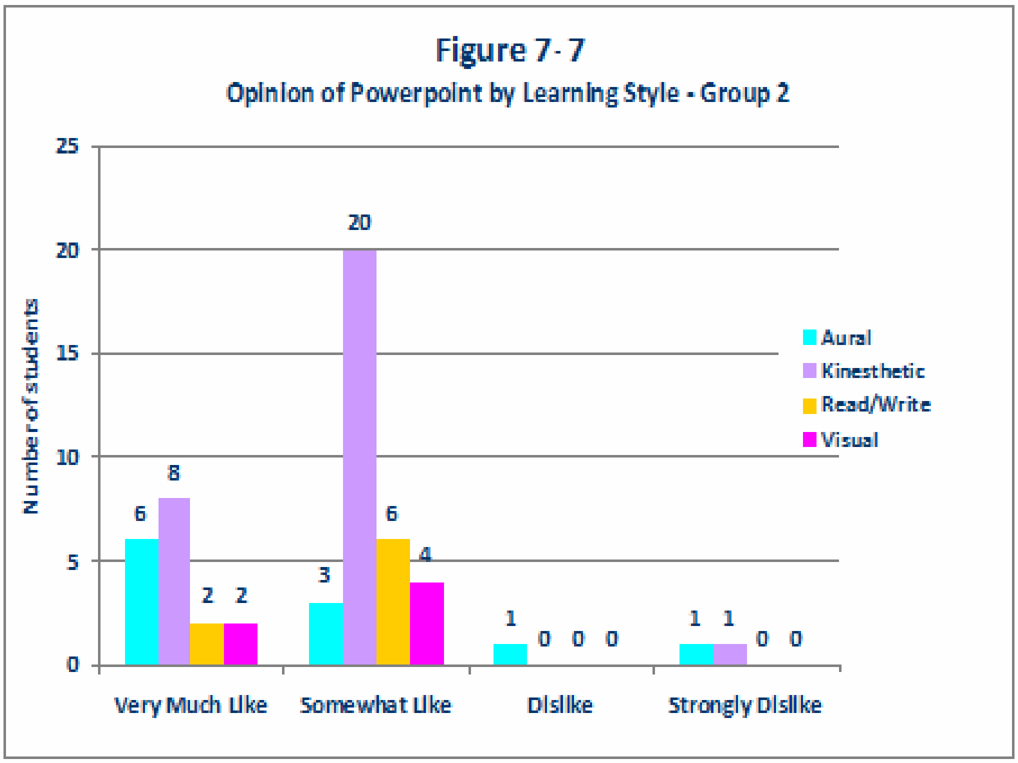


Figure 7-7. Opinion of PowerPoint by Learning Styles –Group 2

In Summary

Figure 8-1 combined these results in numbers. From the survey results, we can easily see that regardless of their learning styles, Group One had negative reactions to the PowerPoint approach while those from Group Two responded more positively. The learning styles from Group Two do not have as much influence as the students' response to the PowerPoint approach. This means that when the PowerPoint presentation is properly prepared, students can certainly benefit from it.

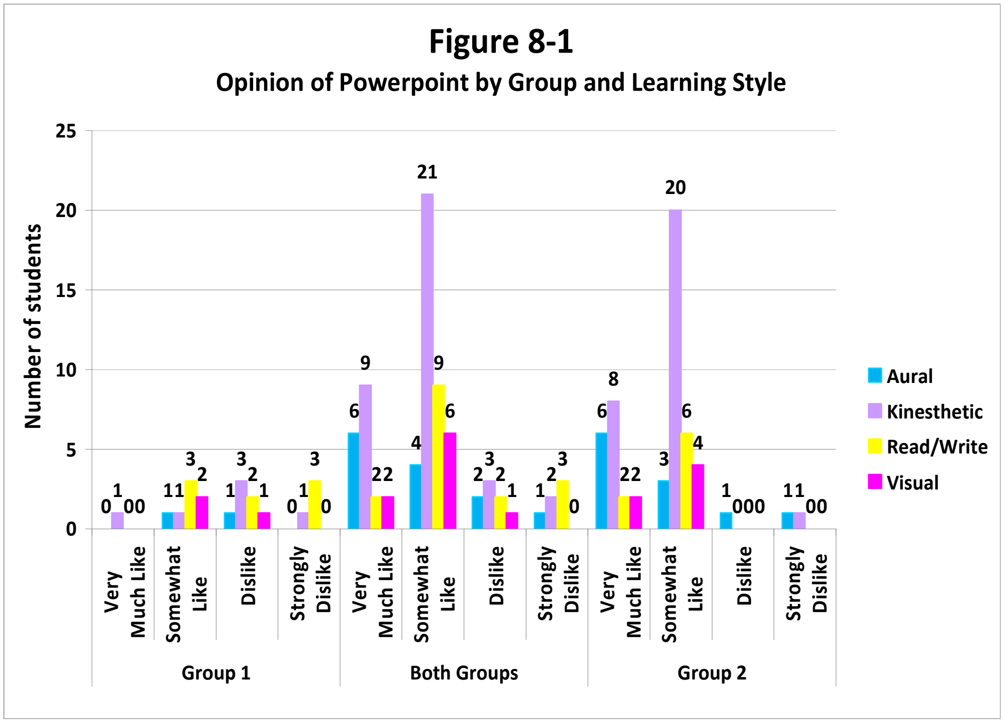


Figure 8-1. Opinion of PowerPoint by Learning Styles – Combined

Conclusions

1. The majority of our engineering students were found to be "kinesthetic" or "read-write" in their learning approach. Engineers are strongly oriented towards explanations, mathematics, and "hands-on" experience. Certainly our labs are opportunities to "experience" the theory, but could we be doing a better job in connecting theory to its meaning in the real world? Ideally, a student is able to relate the mathematical model to the reality it represents. The question also arises whether there is a preferred cognitive profile for an engineering student.

2. Cognitive load theory would seem to be a very reasonable explanation for why students dislike PowerPoint use in a technical course. Short-term memory is capable of storing only a limited amount of data. Seeing all the figures and equations in a large panorama available throughout the explanation allows a student to constantly refresh short term memory.

3. The animated add-in PowerPoint approach was used in one course only for development of concepts. Example problems were still done on the board. A second class did not have any experience with the animated PowerPoint. Students who had experience with the animated figure and equation style PowerPoint were much more favorable to technical

lectures using PowerPoint than those who had not used these in a class. This approach is worth developing further.

4. The enhanced PowerPoint presentation requires an extremely large amount of time in preparation, but the survey results reveal that the students, regardless of their learning orientation, find it better than the typical type of PowerPoint presentation.

The next refinement of the PowerPoint approach will be to combine animated PowerPoint with some partial handout notes, where a portion of the figure or equation is presented on paper. This should involve the student more, including reading and writing, while still exposing the figures and equations a little at a time.

The present study is viewed as a first attempt to understand the cognitive styles of our students. Future studies will look at the learning style differences between mechanical engineers and other majors and at students' preference for various PowerPoint approaches.

Bibliography

1. Lee, B. Kyun, Graff, R. Williams and Leiffer, Paul R., "Psychological Considerations in Engineering Teaching: An Ethical Mandate to Produce Responsible Engineers," Proceedings of the 2008 ASEE annual conference

2. Chandler, P. & Sweller, J. (1991). "Cognitive Load Theory and the Format of Instruction". *Cognition and Instruction* **8** (4): 293–332.

3. Kozhevnikov, M., "Cognitive styles in the context of modern psychology: Toward an integrated framework of cognitive Style," *Psychological Bulletin*, *133*(*3*), 464-481, 2007.

4. Klein, G. S., & Schlesinger, H. J., "Perceptual attitudes toward instability: Prediction of apparent movement experiences from Rorschach responses," Journal of Personality, *19,* 289-302, 1951.

5. Klein, G. S., "A personal world through perception. In R. R. Blake and G.V. Ramsey (Eds.) Perception: An approach to personality," 328-355, 1951.

6. Witkin, H. A., Lewis, H. B., Hertzman, M., Machover, K., Bretnall, P. M., & Wapner, S. "Personality through perception: An experimental and clinical study," New York: Harper & Brothers, 1954.

7. Messick, S., "Personality consistencies in cognition and creativity. In S. Messick (Ed.)," Individuality in learning, 4-23. San Fransisco: Josey, 1976.

8. Keefe, J.W. "Development of the NASSP learning style profile. In J.W. Keefe (Ed.)." Profiling and utilizing learning style (pp. 1-28). Reston, VA; National Association of Secondary School Principals, 1988.

9. Rayner, S., & Riding, R., "Towards a categorization of cognitive cycles and learning cycles," Educational Psychology, 1-5, 1997.

10. Curry, L. "An organization of learning styles theory and constructs," ERIC Document, 235, 185, 1983.

11. Cagiltay, N. E., "Using learning styles theory in engineering education," European Journal of Engineering Education, 33 (4), 415-424, 2008.

12. Eder, W. E., & Hubka, V., "Curriculum, pedagogies and didactics for design education," Journal for Engineering Design, 16(1), 45-61, 2005.

13. Hativa, N. & Birenbaum, M., "Who prefers what? Disciplinary differences in students' preferred approaches to teaching and learning styles," Research in Higher Education, 41(2*),* 209-236, 2000.

14. Holvikivi, J., "Learning styles in engineering education: The quest to improve didactic practices," European Journal of Engineering Education, 32(4), 401-408, 2007.

15. Mastor, K. A., & Ismail, A. H., "Personality and cognitive style differences among matriculation engineerings and information technology students," World Transactions on Engineering and Technology Education, 3(1), 101-105, 2004.

16. Zimmerman, A. P., Johnson, R. G., Hoover, T. S., Hilton, J. W., Heinemann, P. H., & Buckmaster, D. R., "Comparison of personality types and learning styles of engineering students, agricultural systems management students, and faculty in an agricultural and biological engineering department," American Society of Agricultural and Biological Engineers, 49(1), 311-317, 2006.

17. Carver, C.A, Howard, A. R., & Lane, W. D., "Enhancing student learning through hypermedia courseware and incorporation of student learning style," IEEE Transactions on Education, 42(1), 33-38, 1999.

18. Fleming, N. D., *VARK Version 7.0: A guide to learning styles*. Retrieved from http://www.vark-learn.com/documents/The%20VARK%20Questionnaire.pdf, 2006.

19. Fleming, N. D. and Mills, C., "Not another inventory, rather a catalyst for reflection," To Improve the Academy, 11, 137, 1992.

Appendix 1:

STUDENT SURVEY – LEARNING IN ENGINEERING

Participation in this survey is voluntary. The results of the survey will be accumulated and shared with the members of ASEE(American Society of Engineering Educators) only. No individual results will be reported on or connected to any faculty, staff or student respondent. You must be 18 or older to participate this survey. Do not sign your name.

* **Year (circle one):** Freshman Sophomore Junior Senior

1. You are helping someone who wants to go to your airport, town centre or railway station. You would:
   a. go with her.
   b. tell her the directions.
   c. write down the directions.
   d. draw, or give her a map.
2. You are not sure whether a word should be spelled `dependent' or `dependant'. You would:
   a. see the words in your mind and choose by the way they look.
   b. think about how each word sounds and choose one.
   c. find it in a dictionary.
   d. write both words on paper and choose one.
3. You are planning a holiday for a group. You want some feedback from them about the plan. You would:
   a. describe some of the highlights.
   b. use a map or website to show them the places.
   c. give them a copy of the printed itinerary.
   d. phone, text or email them.
4. You are going to cook something as a special treat for your family. You would:
   a. cook something you know without the need for instructions.
   b. ask friends for suggestions.
   c. look through the cookbook for ideas from the pictures.
   d. use a cookbook where you know there is a good recipe.
5. A group of tourists want to learn about the parks or wildlife reserves in your area. You would:
   a. talk about, or arrange a talk for them about parks or wildlife reserves.
   b. show them internet pictures, photographs or picture books.
   c. take them to a park or wildlife reserve and walk with them.
   d. give them a book or pamphlets about the parks or wildlife reserves.
6. You are about to purchase a digital camera or mobile phone. Other than price, what would most influence your decision?
   a. Trying or testing it.
   b. Reading the details about its features.
   c. It is a modern design and looks good.
   d. The salesperson telling me about its features.
7. Remember a time when you learned how to do something new. Try to avoid choosing a physical skill, eg. riding a bike. You learned best by:
   a. watching a demonstration.
   b. listening to somebody explaining it and asking questions.
   c. diagrams and charts - visual clues.
   d. written instructions – e.g. a manual or textbook.
8. You have a problem with your knee. You would prefer that the doctor:
   a. gave you a web address or something to read about it.
   b. used a plastic model of a knee to show what was wrong.
   c. described what was wrong.
   d. showed you a diagram of what was wrong.
9. You want to learn a new program, skill or game on a computer. You would:
   a. read the written instructions that came with the program.
   b. talk with people who know about the program.
   c. use the controls or keyboard.
   d. follow the diagrams in the book that came with it.

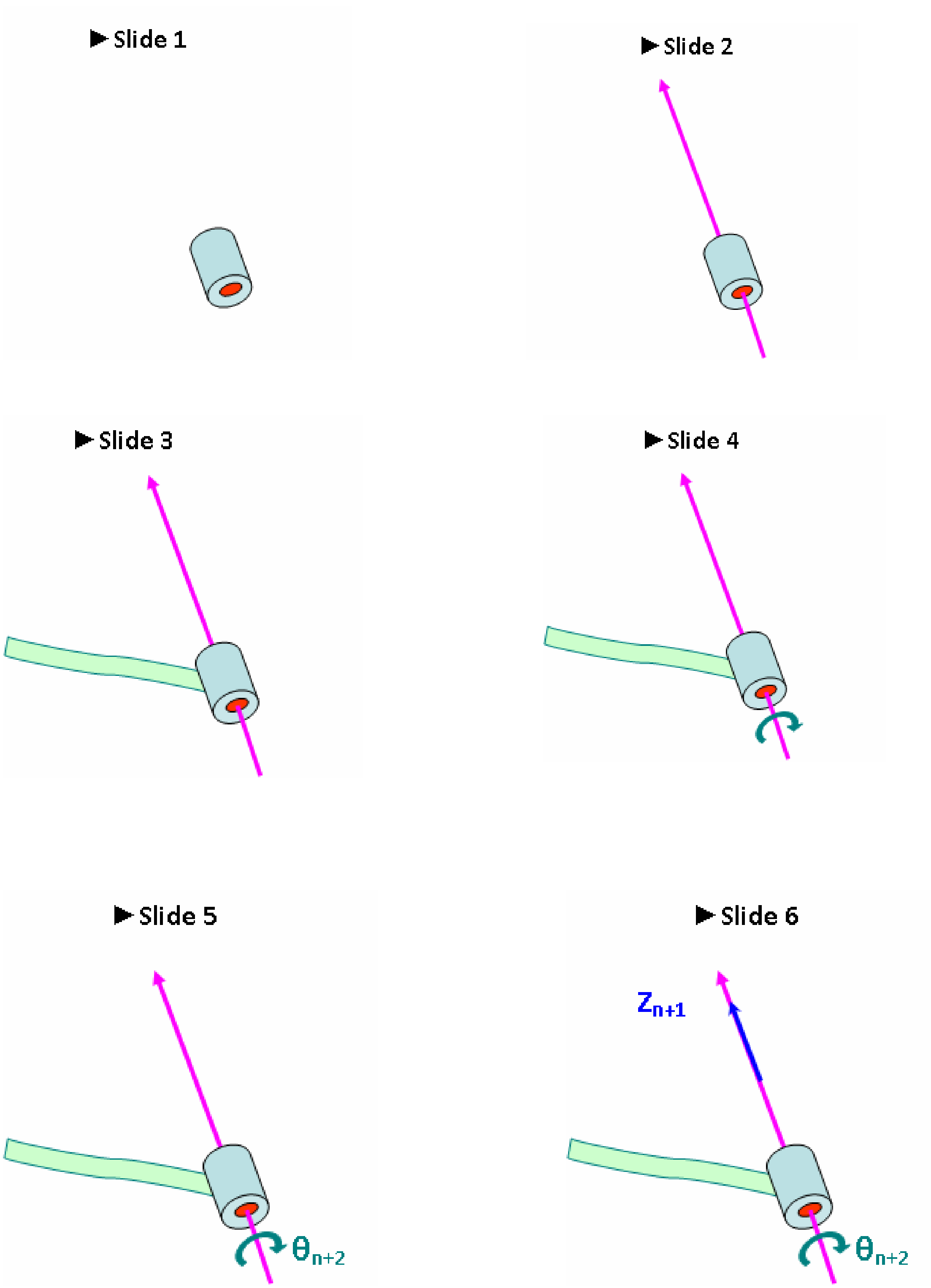
10. I like websites that have:
    a. things I can click on, shift or try.
    b. interesting design and visual features.
    c. interesting written descriptions, lists and explanations.
    d. audio channels where I can hear music, radio programs or interviews.
11. Other than price, what would most influence your decision to buy a new non-fiction book?
    a. The way it looks is appealing.
    b. Quickly reading parts of it.
    c. A friend talks about it and recommends it.
    d. It has real-life stories, experiences and examples.
12. You are using a book, CD or website to learn how to take photos with your new digital camera. You would like to have:
    a. a chance to ask questions and talk about the camera and its features.
    b. clear written instructions with lists and bullet points about what to do.
    c. diagrams showing the camera and what each part does.
    d. many examples of good and poor photos and how to improve them.
13. Do you prefer a teacher or a presenter who uses:
    a. demonstrations, models or practical sessions.
    b. question and answer, talk, group discussion, or guest speakers.
    c. handouts, books, or readings.
    d. diagrams, charts or graphs.
14. You have finished a competition or test and would like some feedback. You would like to have feedback:
    a. using examples from what you have done.
    b. using a written description of your results.
    c. from somebody who talks it through with you.
    d. using graphs showing what you had achieved.
15. You are going to choose food at a restaurant or cafe. You would:
    a. choose something that you have had there before.
    b. listen to the waiter or ask friends to recommend choices.
    c. choose from the descriptions in the menu.
    d. look at what others are eating or look at pictures of each dish.
16. You have to make an important speech at a conference or special occasion. You would:
    a. make diagrams or get graphs to help explain things.
    b. write a few key words and practice saying your speech over and over.
    c. write out your speech and learn from reading it over several times.
    d. gather many examples and stories to make the talk real and practical
17. What would you say is your learning style?
    a. Auditory b. Visual c. Read/Write d. Kinesthetic
18. How confident are you with your mathematical ability?
    a. Very confident. b. Reasonably confident c. So-so d. Not very confident
19. By which method do you think that you would learn technical material better?
    a. If it was given as a PowerPoint presentation by the instructor.
    b. If it was a lecture presented by the instructor writing on the board.
20. How do you like the PowerPoint presentation specially prepared for engineering classes?
    a. Very much. b. Somewhat c. Dislike d. Strongly dislike

Thank you for your participation.

Appendix 2:

Partial Example of Progressively Prepared Presentation Using PowerPoint

Figure 7-7. Opinion of PowerPoint by Learning Styles –Group 2



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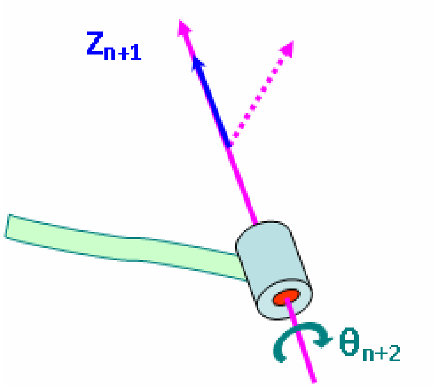

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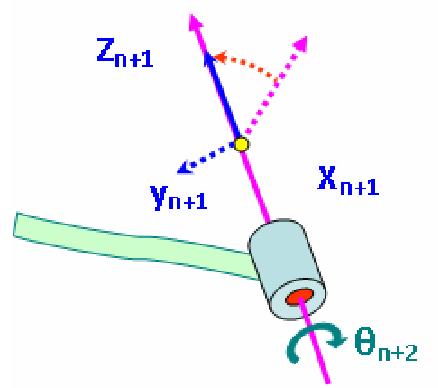

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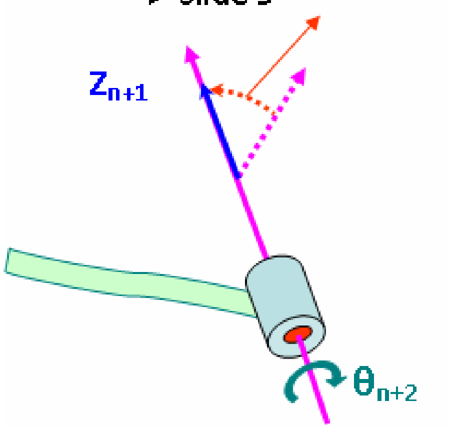

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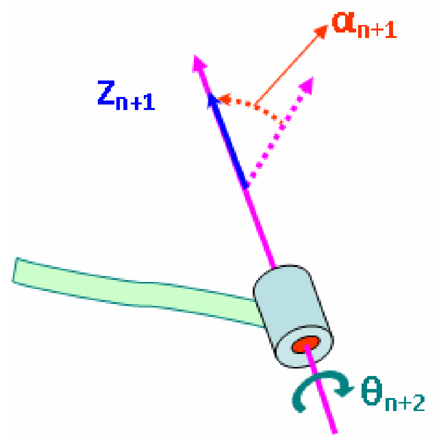

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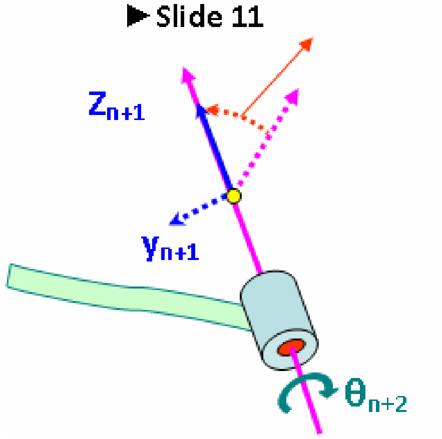

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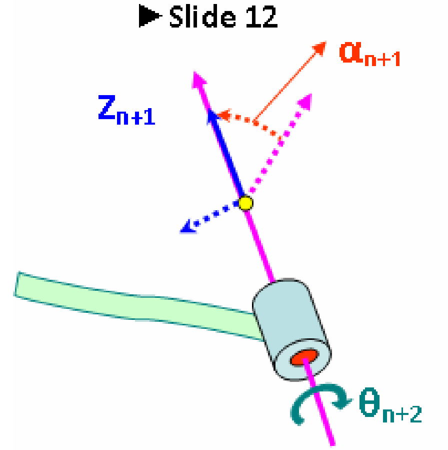


Appendix 3:

Two Modes of Learning

As students develop in their ability to model problems with equations they begin by going back and forth between the physical domain and the analogous mathematical domain. Eventually they become very proficient in working problems strictly in the mathematical/theoretical realm. As they push the mathematics to the limits, as physicists often do, they sometimes discover new physical concepts and principles. An example is the recent search for the "memristor," a fourth component in electrical theory that "needed to exist" because of the symmetry and completeness of the mathematical description of the other 3 basic elements in circuit theory.

It has been observed that there are two different modes of learning. One is series or linear and logical; the other is parallel or intuitive. We learn a language by parallel means. You cannot hand a dictionary to a baby and expect him to learn a language, but he does so by observation, trial-and-error, and experience. Information comes to him from many parallel sources and he categorizes that information into language. This parallel learning is also the way students learn to operate computers nowadays – by trial and error, "guess and check".

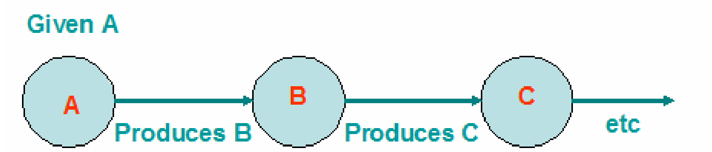
The series method of learning is less natural and more dependent on training oneself to think in a logical stream. This method of thinking is more often taught or deliberately self-learned than simply "picked up" at random, and it is best taught through the discipline of learning mathematics, especially plane geometry, with its axioms and proofs. This type of learning requires a different kind of discipline than parallel learning, which depends more on memorization and repetition than the series type. Series learning requires discipline and a sense of anticipation that the process will result in an answer, even if one does not intuitively understand what the answer will be. As an example, in the study of plane geometry, some facts are obvious, such as that the shortest distance between two points in space is a straight line, but through a chain of linear reasoning, one can find out other facts that not only are not obvious but may even be counter-intuitive. Engineering students must learn the linear thinking process to be successful. Actually, I find that both methods are necessary, but technical students tend to use linear reasoning more than liberal arts students.

The best predictor of passing engineering courses is a thorough previous education in algebra. Students who have relied on their calculators to solve algebra problems do not do well in engineering courses.

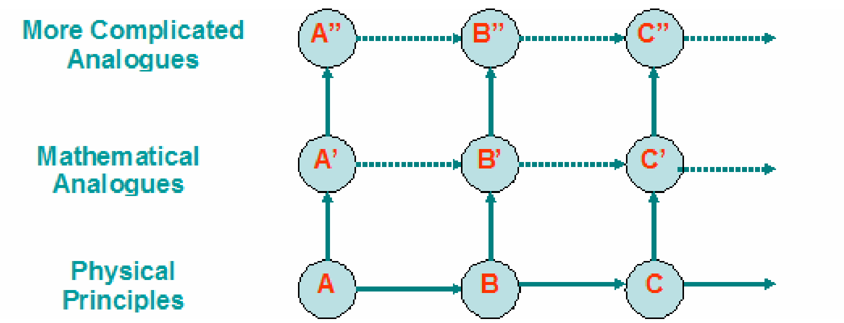
Students today are used to learning by computer, in which case you try something and see if it works, and if it doesn't, you try something else until it does work. They work problems in the same way; they are not used to working carefully and logically (linearly) so that they are confident in each succeeding step. Therefore if they don't have numerical answers to their problems, they are lost.

Presently Geometry, Algebra and Trigonometry courses are being degraded in our high schools in order to make room for Calculus. It would be better to teach the previous courses more thoroughly, without the use of calculators, and leave the Calculus courses until college.

Linear reasoning in engineering can be illustrated by the following diagram:



Probably the best illustration begins with the axioms of Geometry, which lead to more complex results. The student then applies this same type of thinking to Algebra, then Trigonometry and higher mathematics. This establishes a mathematical framework to which the student can correlate with physical principles. Then one learns to represent physical principles by mathematical means. After some study the physical principles are mentally reduced to mathematical analogies.



Familiarity with these mathematical analogies leads to more complex analogies which can be used to analyze and represent the physical properties in more complex ways.

For example, in the study of Electrical Engineering, Ohm's law and basic differential equations for circuit elements suggest mathematical analysis by mesh and loop equations. Time dependence can be related to complex variable analysis; thinking of a circuit as represented by complex numbers leads to phasor diagrams; the systems are reduced by transformations from the time domain to the frequency domain; students begin to think in the frequency domain instead of in the time domain; instruments are developed to present the major data in the frequency domain (spectrum analyzers). Eventually the addition of noise into a communication system can be represented by dots on the screen of a more complicated instrument, to determine the best methods of coding for communications systems.

Notice that the education of engineers moves in a linear way from physical reality to more complex mathematical models, but each model depends upon a previous model.

Obviously, this process is not exclusively linear; all along the way parallel thinking is employed, in order to learn concepts and definitions by repetition and trial-and-error. But the basic overall process is linear.

Another related property of linear thinking, as employed by engineers, is yes-no, right-wrong, black-white reasoning which is used in categorization. This is very similar to the first stage defined by the Perry model.