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Assessing Chalk & Talk and Power Point Presentation Techniques for Teaching Engineering Courses*

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The paper discusses the curriculum delivery modes to promote teaching and learning of engineering in universities. The current modes of instruction are the traditional chalk & talk and PowerPoint presentations. The latter completely depends on the rapid growth and adoption of modern ICT in enhanced teaching classrooms and environments. The study is based on the literature and extended teaching experiences of the authors in different universities in Africa, Europe and North America. Anecdote information obtained from fellow academics and consultation with students were also used in the paper. The discourse covered the advantages and disadvantages of each method. Because of the complex nature of engineering education, either of the delivery modes may not be adequate to cover all courses or topics required in a program for professional accreditation. As a result, it is recommended that instructors should use a hybrid technique consisting of chalk & talk and PowerPoint, having determined which area of the course will benefit significantly from either technique

Keywords: engineering education; lecture delivery methods; PowerPoint; chalk & talk

1. Introduction

Current engineering education contains many examples of technology use to support students' learning, however most of these examples are at rather low or fundamental level. The same applies to e-learning, which, in most cases, is restricted to accessing the teaching material using a computer and/or virtual learning environment. The material accessed is typical PowerPoint presentations, in which lecture notes are prepared and stored.

PowerPoint is likely the most used presentation software in classrooms in many universities around the world. Although, originally used as a supporting tool, it has been gradually embraced by academia, including engineering instructors. The use of PowerPoint "provides the lecturer with the opportunity to clearly present their work in a variety of written, graphical and visual formats" [1], and is a radical shift from traditional chalk & talk method of teaching. This has led to an increasing emphasis being placed on the electronic delivery of lecture material, typically by means of PowerPoint presentations. This is partly driven by the universities' investment in IT equipment and the reduction in class contact hours.

PowerPoint gradually becoming a primary delivery mechanism makes it possible to use general teaching spaces for all disciplines, without any need for tailored classrooms. Classrooms and lecture theatres accommodating large classes are often dominated by big projection screens and have limited whiteboard space, inhibiting the capability of the lecturer to demonstrate the reasoning underlying mathematical problem-solving processes. It also diminishes interaction, and meaningful engagement, characteristic of traditional lecture. It can be argued that a shift from the traditional chalk & talk genre, to a genre based predominantly on static PowerPoint slides, makes the situation convenient for university administration, which can now timetable across the institution for generic disciplines, rather than faculty or discipline-based class allocation [2]. General teaching spaces, no longer tailored to the needs of a specific discipline, may have, as a loop, also contributed to further swing from traditional chalk & talk pedagogy to the use of PowerPoint presentations. Institutions readily accept the change from actual teaching to appropriate presentation of the material. In some institutions, the classroom arrangement hinders simultaneous slides presentations and writing on

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the whiteboard/blackboard, as the screen covers the available space.

The application of PowerPoint has been a subject of many studies, mainly related to students' attitude and perception towards its use, its effectiveness in terms of students' performance and information retention. The results are a mixture of those in favour of PowerPoint and those indicating minimal effect of computer-assisted instruction (PowerPoint slides) on student performances. Advocates agree that there is an increased level of students' interest as well as endorsement by the teacher [3], whereas critics argue a weakening of verbal and spatial reasoning [4]. Although, in general, students prefer PowerPoint presentations [5], their information retention and overall results do not necessarily improve [6, 7].

A majority of the studies referred to in the preceding paragraphs are based on data collected from non-technical students, because there is not much literature from mathematics-based disciplines, such as science and engineering. In addition, the studies often use some statistical tools to make conclusions related to students' attitude, preference, results or retention, but there are no studies related to students' learning in general, improvement of their skills in different areas, and ultimately, how the presentation has influenced their choices of professional pathways.

The current paper discusses the use of both traditional chalk & talk and PowerPoint as delivery methods in engineering education. It is not based on students or instructors surveys, therefore there is no statistical analysis, but rather a look at the literature, and using combined years of teaching experience of the authors, and hours of discussions with fellow university instructors, graduates (who in the meantime have become instructors themselves) and students. As a result, the anecdotal ideas presented, and conclusions reached, are entirely opinions of the authors.

2. Chalk & Talk: Traditional Teaching

Chalk & talk is a presentation method often used in engineering in which the speaker conveys and discusses his or her points by using chalk on blackboards or markers on white boards to draw pictures and sketches. Chalk & talk was originally popular in entertainment industry but grew to become a pedagogical tool. According to Donnelly [8], in Educational Technology, chalk & talk is the traditional, formal, directed-teacher method of instruction in which the teacher stands at the front of the class, writes on a board, and explains educational theories, principles and hypothesis to students.

2.1 Features

Lectures and tutorials delivered by using the chalk & talk method have been the main characteristic of traditional face-to-face teaching in engineering for many years. The method has been arguably successful and effective for generations of students in all disciplines, particularly engineering. It often involves writing on the board and talking simultaneously. The obvious problems related to blackboard/whiteboard writing are poor visibility (especially in large classrooms), lack of visual clarity of the material, and issues related to the fact that the instructor normally faces the board and not the students [2]. Also, instructors require the use of supplemental teaching aids, charts, slides and pictures to engage students, maintain interests, and stimulate learning through concepts formation [9].

2.2 Advantages and Disadvantages

However, there are some natural advantages of traditional chalk & talk which are also recognized by students [10]. In terms of the volume of information delivered, slowing down the delivery gives great benefits because students can follow the procedures step by step and make their own notes. The traditional method increases students' engagement with both materials covered and the instructor. A great example is the use of multiple colours of chalk or markers to enhance the student experience, and in engineering, the use of multiple colours is often used to depict various engineering concepts. For example, in a Statics course, one colour could be used to draw a truss, one colour could be used to draw and show external applied forces, and another colour to draw forces from supports. There are many such examples of how engineering has used traditional methods effectively, and in the lecture context, chalk & talk is considered a more interactive approach than using PowerPoint.

This interactivity, or simply ease of communication, is one of the major advantages of traditional lectures. Some researchers argue that writing is part of a social action giving natural interaction between two parties [11]. Often, student feel more comfortable asking questions during a lecture, when it is not typically done using PowerPoint slides. Instructors that use traditional chalk & talk delivery can readily adjust their speed of instruction to meet the needs of the students' pace, which is not an easy task when using PowerPoint. During the traditional method, the instructor simply pays more attention to the students' needs.

2.3 Reasons to use Traditional Chalk & Talk

Students in engineering often indicate that writing

on the board helps in the understanding and retention of lecture materials. They note that this is due to more activity during lectures, which is encouraged in the chalk & talk method [12]. In addition, students also agree that the traditional method of delivery improve their motivation to attend lectures, and this is one of the greatest benefits of the method [13–15].

Writing on the board seems to present an informal atmosphere in the classroom, which can be accompanied by another informal element in the form of sketching or drawing. However, some recent developments and advances in educational technology have been promoting the learner-centred methodology at the expense of 'whole-class' teaching prevalent in chalk & talk with its informal elements like handwriting and sketching [2, 8]. Both writing and sketching are extremely important in engineering education. Engineering profession has its own language of communication, with mathematical symbols and signs, and its own reasoning and presentation. The students' preference to see all steps in the procedure (and to see them sequentially), and to review them, instead of seeing only the completed or final outcome, as often happens in PowerPoint slides, is essential in engineering education. In general, chalk & talk seems to be a suitable methodology for teaching disciplines in which mathematical manipulations or quantitative approach is emphasized, which often involves repeated step by step demonstration examples on how to apply certain models or solve some equations and problems [16].

The aspects of chalk & talk related to handwriting, note taking, and sketching are also of a great importance in engineering. Current engineering students are rarely taught sketching and are seldom required to apply that skill. One of the natural ways for students to learn and practice freehand sketching is through taking notes during lectures, as many engineering concepts are introduced, presented, and explained through drawings, diagrams and plots on the board. Observing the creation of a sketch on the board, and having the opportunity to make a sketch, not only teaches that skill, but also enhances the benefits associated with sketching. The benefits include learning global engineering communication language, clarification of ideas, improvement of spatial ability, and enhancement of problem-solving skills. While promoting communication of ideas, freehand sketching encourages non-verbal learning, which accounts for development of visual cognitive and creative problem-solving skills. It also facilitates expression of abstract conceptual ideas through an improved visual scope of the world. Creative problem solving can especially benefit from sketching as it allows for deeper thinking for solutions than if mental work is solely performed [17].

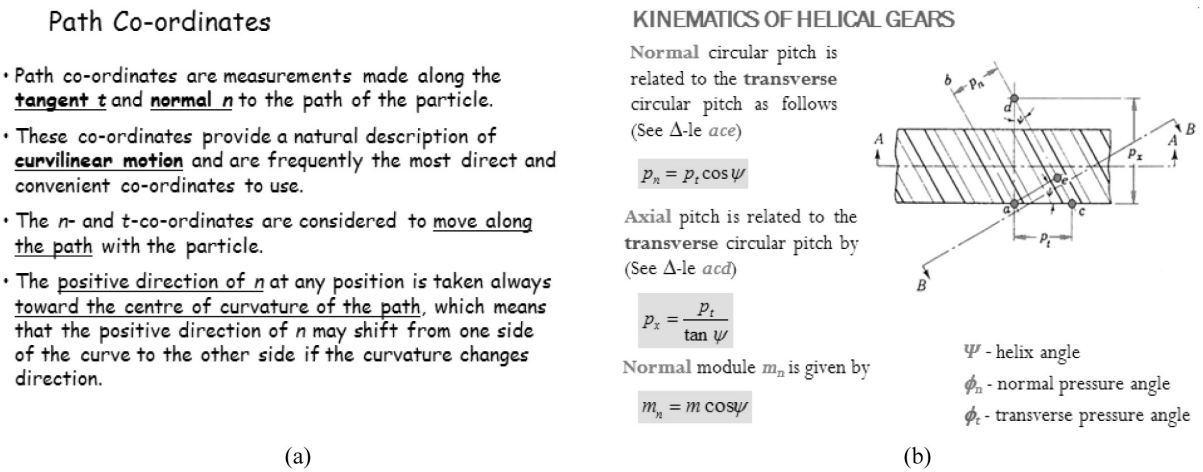
If the chalk & talk teaching methodology is well managed, it can promote learning through brainstorming and engagement, or participation in classroom discussions. It provides students ample opportunity to listen, reflect, and organize their thoughts before making any contribution on the topics covered by the instructor. The method is also very effective in teaching students who are re-taking a course or during tutorials because the instructor can painstakingly explain the materials to foster learning.

Instructors can use the methodology innovatively to assess prior knowledge about topics to be covered; to assess what students have learned and to promote discussions about some difficult or controversial issues [18, 19].

3. Power Point Presentation: Current (Modern) Teaching Methodology

Teaching strategies used always depend on personal preferences of the instructor, but also have undergone changes related to, among others, the technology available in the classroom. Since the latter part of the last century, PowerPoint presentation has become indispensable in lecture halls and conference rooms. The software was originally developed as a tool to improve learning experience by offering the means to make presentations more structured and more entertaining [5].

There are several more modern presentation approaches and new instructional technologies available for engineering education. Nowadays, universities put more and more emphasis on information and communication technology (ICT) and its application in teaching and learning [20]. Educational institutions take advantage of new development using social media, mobile applications, simulations, games and even augmented reality helping students in their learning [21]. Technology supports students learning by allowing them to actively and independently participate in gaining new knowledge and skills. It is also very useful in winning the attention and provide engagement with millennial Z generations [22]. The evolving ICT provides teaching and learning tools in the form of virtual environments, digital games, web-based learning platforms, virtual labs/simulations, social network [23]. Students typically are positive about integration of ICT into teaching however, they also suggest that instructors should themselves be instructed on integrating ICT into instruction to improve its level and to avoid too much dependence on it or non-use [24]. Despite all technological improvements and fast evolving ICT, PowerPoint



(a) (b)

Fig. 1. Examples of simple slides: (a) typical slide following bullet and phrase mode, (b) more informative slide with graphics and equations.

seems to be in many instances the main, if not only, attempt to introduce technology directly into the classroom.

3.1 Features

PowerPoint is an attractive software which can mix text and graphics with some advanced features giving the opportunity to incorporate visual and auditory aspects to a presentation. The presentations can be simple consisting of only text on a screen, but it can also be complex with tables, pictures, graphs, sound feature, visual effects including animations, clips, etc.

PowerPoint can easily add, correct and make changes to the presentations. It allows easy and natural manipulation of text, including spell check, graphics and other multimedia features. The flexibility to remove, add, and edit slides makes adjusting the lecture material practically effortless. Printing of the slides or posting them on a learning management platform is an easy way to provide students with handouts. That, in turn, allows the lecturer to make a presentation more organized and flexible, making PowerPoint a powerful instructional medium. Students can have access to the material ubiquitously to enhance revision and learning.

3.2 Advantages and Disadvantages

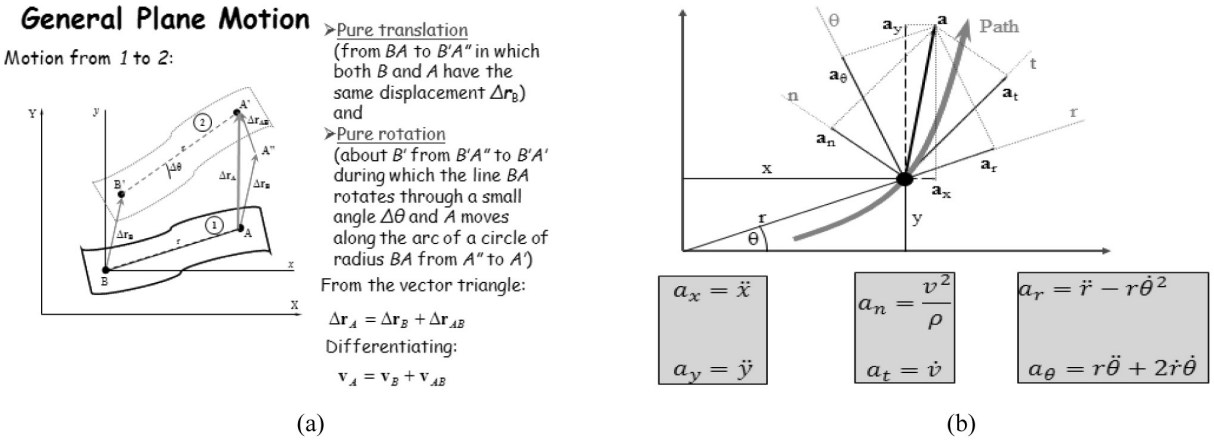
PowerPoint, as a teaching strategy, is a great time saver in comparison to writing on the board. By using the slides in the software, instead of manually writing or drawing on the board, the instructor saves a lot of time, and the order and flow of the presentation is flawless. It also saves a lot of effort, both physical and intellectual, as the instructor simply follows the pre-prepared slides. Editing ability of the software is a powerful tool to make small or fundamental changes to the presentation and update slides according to requirement.

Another advantage is the visual attraction of the presentation which may draw students' attention. If course material contains complex graphs, animations, and figures, students may consider it easier to follow, having also an advantage that an easy handout is readily available as a printout or a file to download. The availability of easy handouts or files, which can be viewed before or after the class, is probably the most appreciated feature of PowerPoint.

In general, PowerPoint makes it easier to present information in an organized and attractive manner to the audience. Some researchers claim that the information presented is easily remembered by the audience [25]. Although, as stated before, some claim better retention of information when attending lectures using the chalk & talk method [12].

Unfortunately, despite frequency of use, PowerPoint slides rarely follow principles of multimedia learning to foster high audience comprehension [26]. They are often used as a guide for instructors for their delivery rather than illustration and help for students to comprehend the material. The default PowerPoint slides' design encourages violation of multimedia learning principles with topic–subtopic structure and its phrase headline approach [27].

Normally, the majority of slides follow the typical layout and bullet/phrase mode (Fig. 1). However, even the introduction of animation, which undoubtedly help students in visualization and comprehension of some problems, may become awkward when they are looked at without animation (Fig. 2). Since, slides are not only used during the actual lecture but also as lecture notes (typically in pdf or graphic format), such slides defeat their educational role.



(a) (b)

Fig. 2. Examples of animation in slides: (a) the slide and still clear without applying animation, (b) slide becoming too cumbersome to read clearly without animation.

There are other issues related to the use of PowerPoint in the lecture context. For example, lack of interaction with students is considered as one of the major disadvantages of the PowerPoint [28]. A good summary of problems related to that is given by Driessnack [29]: ''When a PowerPointTM slide is put on the screen, the students look at the slide, not at me. My voice, suspended in the air, is separated from me. The students do not see me, and I cannot see them'' (p. 347). Some other issues reported are related to uncontrolled speed of lecture; students may quickly feel frustrated and upset when they cannot follow the instructor. Also, the instructor should actively pay attention to students' reaction, however, the instructor may not only ignore those reactions, but even accelerate in order to finish the pre-planned material content. Use of PowerPoint can be a reason for students not being able to concentrate, and thus reducing attention as well as interest in class. Despite the technological potentials of PowerPoint as a software, it may not provide any form of entertainment to a classroom, but rather dullness. Students perceive looking at the slides as boring, non-engaging and tiresome, especially as they are sure to get those slides in the form of a handout or file [30]. That may be a serious issue, especially when the slides are prepared for animation and are looked at without that feature, which may be the most common approach, as instructors tend to provide their PowerPoint files, rather in the readable only format of pdf. In such cases, the students can be even further disengaged, and learning becomes severely compromised.

3.3 Reasons to use PowerPoint

The fundamental reason for making PowerPoint an attractive alternative to the traditional chalk & talk method is the amount of time the instructor can save. Once prepared, presentation can be used several times, with an easy procedure to update, correct, or change depending on the purpose for using the software. A PowerPoint presentation can be modified to suit different audiences or listeners, for example, a research proposal for academic assessment can be re-configured for a funding agency. Additional time can be saved, as many publishers now provide ready-made PowerPoint slides as part of the instructor's support. Therefore, without much effort, an instructor can have presentation material and, using the same slides, can create lecture notes, which are appreciated by students. In addition, the use of 'modern technology', including technologically enhanced classrooms, usually gives high evaluation marks for both the course and the instructor in students' evaluation that is customarily administered for university courses [3]. The time saved using a simplified teaching methodology, i.e., spending less time on lecture preparation and preparation of material for students, can be spent by instructors on their other academic responsibilities, such as publications and administrative duties, which are highly rated for performance of instructors at the universities than 'simple' teaching.

For novice instructors, or those who may not be fully conversant and comfortable with the material, available well-prepared PowerPoint can be very helpful. The safety net of having the presentation on the tip of the fingers, in easy reach of the computer, makes the instructor more confident and relaxed. However, since the confidence is rather artificial the instructor's eyes will still stay focused on the screen rather than on students' faces [28]. PowerPoint forces inexperienced instructors to have some prepared points in the form of bullets, some outline of the lecture, which can be followed without even thinking of what to do next. This

possibility enables the inept instructors to organize themselves, to do things in a logical and systematic way [4].

4. Discussion

Success in student learning has always been associated with the motivation and interest of the student. To that extent, the use of PowerPoint presentation may make the lecture vivid and attractive to students. The graphics, including figures and graphs, typically are far superior to the drawing on the board by instructor in traditional teaching. The pictures can be manipulated, edited and changed easily. They are normally appealing and may enhance meaningful learning. The instructor can present more complex graphical content in less time compared to chalk & talk [31]. On the other hand, students spend more time taking notes as they get the material discussed in class, therefore, may concentrate on the instruction itself.

Is PowerPoint really a better option than traditional chalk & talk in terms of students' understanding of the material, contact with students, their improvement of professional skills (such as communication skills), or even in terms of engagement and possibly entertainment? There are opinions that traditional method gives greater ability for students' understanding of the material, as compared to PowerPoint [30]. The speed at which typical PowerPoint lecture is delivered may make it difficult for an instructor to explain in detail and emphasize clearly each point, argument, or a nuance which (s)he wishes to communicate. In contrast, the speed of delivery as the instructor is writing on the board gives him/her time to highlight important issues and gives students enough time to grasp the essence of the material or ask questions. The students also have a chance to consider and decide what they should be noting. The instructor's natural pauses in the delivery gives students a chance to take a breath and organize their thoughts. Such periods of pause, although understandably short, provides a bit of time to at least comprehend and appreciate the material. As a result, students need less effort outside of the classroom in their learning. The general attitude of students spending as little time as possible on the out of the classroom learning seems to constitute a great advantage of the chalk & talk methodology.

Another aspect which must be considered in comparing chalk & talk and PowerPoint methods for lecture delivery is the students' participation in the class and contact with the instructor. Students claim that the use of the pre-planned slides tend to inhibit questions, as the students hesitate to interrupt the flow of the presentation. Normally, by the time the presentation is finished, the student has either forgotten the issue, or is busy leaving the classroom for the next class or engagement. Additionally, the background or rationale of the question may be lost, and if the problem is indeed addressed, it may not be in the proper context. The contact between the instructor and students is sometimes problematic; to maintain eye contact with students in a semi-dark classroom may be indeed quite a challenge. In such circumstances, some students may be engaged in other activities not related to the lecture without the knowledge of the instructor because of the dark environment.

The issue of entertainment and interest is also not as straightforward as one might imagine. For example, some earlier studies of PowerPoint use suggested that students found it a much more entertaining method of teaching than traditional techniques [32, 33]. However, recent studies found opposite results, claiming the traditional chalk & talk method to be more entertaining for students [30].

The success of any method of delivery depends strongly on the general discipline of the course. Reports indicate that, for instance, mathematics instructors agree on the advantages of chalk & talk over PowerPoint [11, 34, 35]. Also, students' preferences vary depending on the subject, and the traditional method is preferred where the course contains numerical information and manipulation, as compared to courses containing complex graphs and figures, where PowerPoint presentations are considered advantageous. Overall, students appreciate the structural advantages of PowerPoint, its graphical qualities, enhancement of visual style of learning, online availability of the lecture material, and the possibility of instant access to a hard paper copy, even before the class [36].

The engineering profession, as well as engineering education, has its own features, language, symbols, methodologies, conduct and practice. Successful engineering student, and ultimately an engineer, should possess sound mathematical knowledge, good understanding of the technical content, and good interpretation skills and imagination. To function in the profession, an engineer should also be able to communicate, both verbally and in writing, which in engineering, includes communication through drawings and sketches. In that context, the question of whether it is important that the instructor covers more content in less time during a lecture is rhetorical. Rather, the significance is the level of understanding of the material and additional skills developed in the process, including that of freehand sketching and note taking. Taking notes highly benefits the learning

process and revising own notes before the assessment contributes to better performance.

Both students and instructors complain about the impact of using slides in lecture [37] as it removes soul and vigour from classrooms. The application of slides removes important, and vital, element of lecturing, which is adjusting material in response to audience reactions and developing spontaneous examples and explanations to clarify and expand on topics. Instead, slides drive the lecture not allowing for modification or augmentation of the displayed material in situ.

There are attempts to overcome such disadvantages by using methods to add annotations to slides. Classroom Presenter, a combination of PowerPoint slides and freehand "inking", the "eClass" or "Classroom 2000" are examples of such software [38]. However, such attempts are adaptation of technology not necessarily driven by demands of teaching.

The teaching methods in engineering education should explore possibilities of providing students with clear and deep understanding of ideas and material content. That can be most likely achieved by presenting the material in a way which will emphasize a step by step process, especially in deriving equations and solving problems. The delivery should also provide the opportunity for interaction between the instructor and students so that they have a common understanding within engineering context and its highly mathematical content [2]. Those objectives can be achieved by traditional teaching in the form of chalk & talk. The approach can also provide the base for the development and practice of both note taking and freehand sketching. The preferred way in which students can learn important engineering skills has been drastically reduced, if not eliminated completely, by the introduction of 'smart' teaching technology, mainly PowerPoint [17]. Additional benefit of chalk & talk method is improving the students' attendance in class, which is very important in terms of achieving higher academic performance. As mentioned earlier, the traditional delivery is an incentive for students to attend class, as PowerPoint is associated with poor and irregular attendance [13–15].

5. Conclusions and Recommendations

Meaningful learning by students is influenced by, among other features, the instructional delivery mode employed by the instructor. It is true that traditionally, chalk & talk lectures and tutorials have been the predominant form of instruction in all disciplines, including engineering. However, that has changed with the introduction of PowerPoint software which is currently the most used approach in any university level pedagogy, including engineering programs.

Advocates for the use of PowerPoint indicate that application of that software increases visual quality of the learning process, benefits an instructor by giving him or her confidence, and saves time in the presentation with the possibility of covering more content material in less time. The software allows for easy editing and adoption to particular needs and inclusion of smart graphics, for example, animation, video clips, etc.

No one can argue against the benefits of PowerPoint, and it is not the intention to do so in this discourse. It is also not necessary to argue against its adoption and use. However, a bit of common sense, so important in engineering, plus years of teaching experience, gives some other considerations on delivery of technical courses.

For engineering courses, which are abstract and mathematical by nature, the objective is to present the material in a way which will provide for solid and deep understanding of the material. In order to achieve such a goal, the process, derivation and analysis, formulation and solving of a problem should be presented step by step, at a pace adjusted to the audience. That can only be achieved with interaction between students and the instructor. That can be accomplished by using PowerPoint, but it is much more effective by using the traditional chalk & talk method.

The argument in this discourse is not to 'ban' PowerPoint from the university classrooms, especially those in engineering, but to use it as a tool when it gives a real advantage. It is obvious that when teaching engineering design, the charts, tables, empirical formulae, and detailed drawings of gears or bearings are much better presented using PowerPoint, and not the board. That also applies to slides prepared not in traditional way, following the templates available in software, but specially designed to engage students, motivate them and at least trying to improve visualization of problems.

However, when the course involves working 'from the first principles', both to explain the theory, and in problem solving, the chalk & talk method is a better option. That applies to all fundamental courses like mathematics, mechanics, thermo-fluids, control, and any other course where sketching of the problem, free body diagram and showing step by step process, starting at the fundamental definitions or principles is cardinal. It does not mean eliminating PowerPoint completely, but it must be used selectively not to overwhelm students with notes taking, or to present some complicated graphics, animation, illustration of the key concept, or even as an entertaining element of a lecture. It should also be used to provide students with

supplementary material that is available online for viewing at their convenience after class.

An engineering academic should be avid and flexible in the use of a hybrid method. Therefore, it is recommended to use both methods depending on the course, material, audience and purpose. Integrate the advantages that are inherent in both techniques to deliver any engineering course. Use engineering common sense to assess those features and think on what the best benefit for students is, rather than for the instructor, bearing in mind that a lecture is not an academic paper presentation at a conference or a seminar.

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