PEDAGOGICAL IMPACT OF THE MULTIMEDIA ENHANCED ELECTRONIC TEACHING SYSTEM (MEETS) ON THE DELIVERY OF ENGINEERING COURSES

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Abstract: This paper presents an innovative practice based on the Multimedia Enhanced Electronic Teaching System (MEETS). The practice was developed and successfully implemented for a core undergraduate course in Mechanical Engineering on mechanics. The MEETS was rigorously designed in response to the growing need of effectively teaching courses with large enrolments, while still allowing demonstrations, which traditionally have been limited to smaller classes. The MEETS includes (i) two video projectors, (ii) two document cameras, (iii) a personal computer (PC) for showing animations, and (iv) the Easel Paper Dispenser Display Adapter (EPDDA), which allows the lecturer to write lecture notes on an area of a letter sized sheet of paper. Images from the EPDDA are shown using one of the document cameras. The lecturer controls which images are shown on the video projectors.

Keywords; multimedia presentations, teaching of mechanics, visual aids, large classes, pedagogical impact, recording of lectures.

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1. INTRODUCTION

In the teaching of University level courses on mechanics, it is critical to clearly explain and demonstrate the motions of machines with appropriate diagrams, live demonstrations and animations. The authors developed several methods to effectively display such motions of machines. These include creating animations using a PC, such as Cleghorn (2005), and fabricating physical models for display using a document video camera, such as Cleghorn and Dechev (2003). To accompany the demonstrations, lecture notes were presented using a traditional overhead projector and transparency roll.

In the past decade, PowerPoint has been commonly employed by University and College instructors. However, employing PowerPoint incorrectly may give rise to difficulties. There could be less participation by the students and a tendency to present material at too high of a

pace for the students to follow. As Brown (2009) argues, the use of instructional technology is not beneficial to teaching or learning when the purpose is not clear and it is merely used as a "placeholder". In addition, good use of instructional technology engages the students in active learning and supports interactive demonstrations. Two years ago, the first co-author surveyed the undergraduate students in his Mechanical Engineering course. They indicated their strong preference to take handwritten notes from material written by the instructor during lectures either on transparencies or the chalkboard.

The preference of the Engineering students was to be actively engaged in the learning process during lectures rather than view projected still PowerPoint images. This is completely consistent with Bonwell and Eison (1991) that in-class writing is productive and ensures students are thinking about the notes that they are writing during lectures.

More recently, tablet PCs are being used to overcome the challenges of static PowerPoint lectures and have gained a wider acceptance for University and College teaching. The tablet PCs have the following advantages over traditional chalkboards and whiteboards:

(i) There is no need to periodically erase material.
(ii) It is possible to review previously presented material (i.e., go backward).
(iii) Projected images can be much larger and more suitable for large classes.
(iv) Other media, such as video, may be incorporated to support presentations, and there is no need to employ separate equipment.
(v) One can more easily overlay annotations on prepared images.
(vi) The instructor may remain facing the students, allowing more effective presentations without the instructor having to turn away for writing.
(vii) It is not essential for the instructor to remain front and centre in the classroom. Students may concentrate on the material being presented on the projection screen, while the lecturer is off to one side.
(viii) One can archive and replay presentations after lectures, and publish to course management systems.

The above advantages are considerable, and should be incorporated as much as possible in any new procedure.

There are currently record numbers of students enrolled in the Mechanical Engineering program at the authors' university. It is therefore important to have methods which are effective for teaching large classes. For an undergraduate Engineering course on mechanics, it remains extremely beneficial to display the motions of machines. With the ever increasing demands to deliver advanced Engineering course content and ensure students are absorbing the complex material, one obvious option is to develop a means whereby the entire lecture content including the creation of real time mechanical drawings, classroom physical demonstrations (e.g., automotive mechanical components) could be recorded and viewed by students on demand.

This paper presents the Multimedia Enhanced Electronic Teaching System (MEETS), which was intentionally designed for the teaching of large classes, and successfully implemented for a core undergraduate course in Mechanical Engineering. Although the paper presents the results for the teaching of one course on mechanics, the authors believe that the advantages of using MEETS are more universal and can be extended to courses in other disciplines.

2. THE MULTIMEDIA ENHANCED ELECTRONIC TEACHING SYSTEM (MEETS)

2.1 Overview of the MEETS

The MEETS presented in this paper combines and enhances the techniques which were previously employed by the authors. The MEETS uses two high definition document cameras to project hand written notes, illustrate mechanical drawings as they are created, and demonstrate small mechanical systems. Brooks-Young (2007) states that the use of document cameras for teaching helps students in learning new concepts. The MEETS retains the advantages of employing a modern tablet PC, the ease of use of the conventional transparency roll, and is effective for teaching large classes.

Figure 1 illustrates the subsystems and interconnections of the MEETS, which includes two video projectors, and two document cameras. Video projector 1 shows images from either the EPDDA (described in Section 2.2) or from the PC. Video projector 2 is always connected to document camera 2.

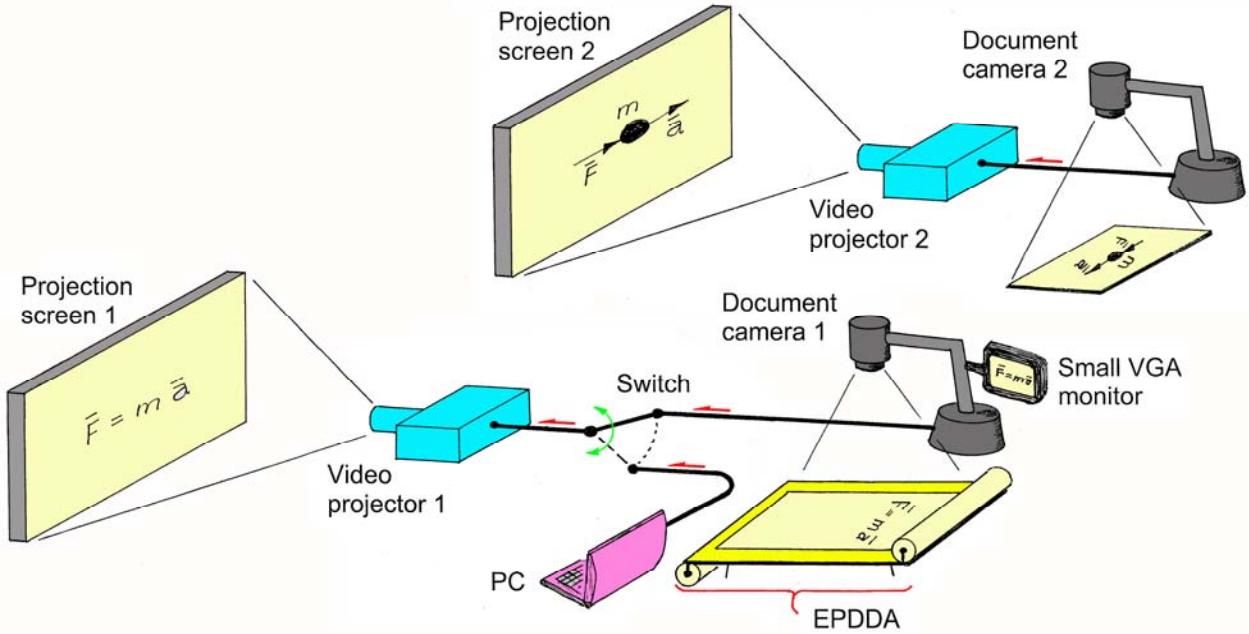


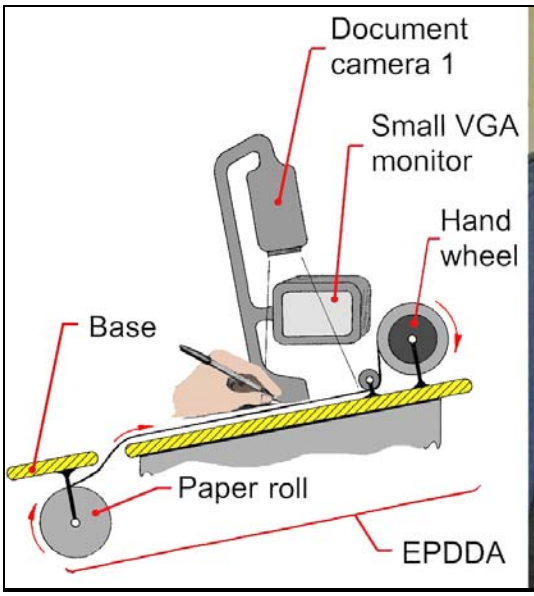
Figure 1 Subsystems and Interconnections of the MEETS.

2.2 The Easel Paper Dispenser Display Adapter (EPDDA)

The EPDDA, along with a document camera and video projector, has some similarities to a traditional transparency roll and an overhead projector. However, instead of a transparency roll, the EPDDA incorporates a paper roll, originally produced for a large-format printer, but modified by trimming to a 30 cm width.

Figure 2 illustrates a schematic of the EPDDA. The modified paper roll is mounted on the feed spool, and its end is fed through a slot in the base of the EPDDA, and onto the take-up spool. Document camera 1 is directed onto the flat portion of the paper on the base of the EPDDA, approximately the size of a letter sheet of paper. The feed and take-up spools are connected to easy to use hand wheels. The instructor may advance the paper by turning the hand wheel

connected to the take-up spool, causing the projected images to move slowly upward. The hand wheel on the feed spool may be turned to go back for review purposes. It is also possible to project images from a sheet of letter-sized paper when placed in the viewing area. The sheet may be transferred to document camera 2 so that the EPDDA may be used. The small VGA monitor (17 cm) is intentionally mounted next to document camera 1, and is intended solely for the instructor. The monitor shows the same image as displayed on video projector 1 and acts as a viewfinder for the instructor. Figure 3 shows a photograph of the EPDDA in use.



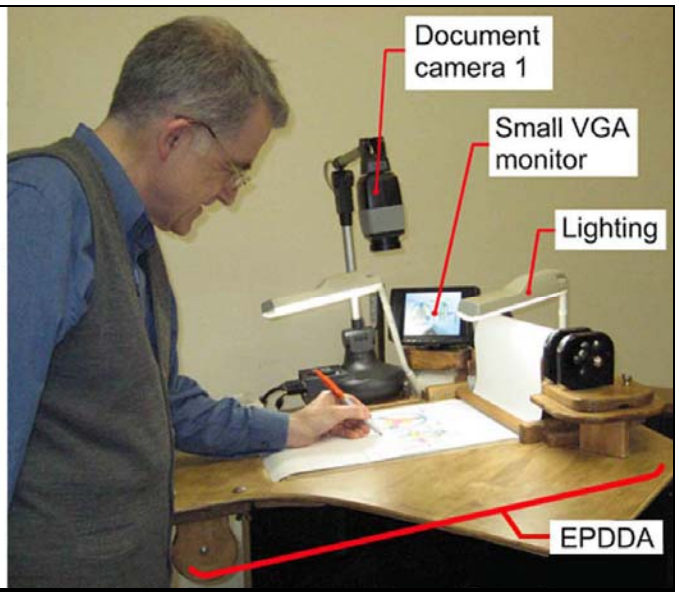


Figure 2 Schematic of the EPDDA. **Figure 3 The EPDDA in Use.**

3. IMPLEMENTATION OF THE MEETS

Prior to lectures, files of illustrations to be covered are posted on the course management system (Blackboard) website. The students are required to print hard copies and bring them to the lectures.

The instructor generally employs the following steps for covering an example:

(i) Demonstrate either a physical mechanical system using document camera 1 or an animated motion using the PC (display on video projector 1).

(ii) Show an illustration of the system printed on a page of letter sized paper (display with document camera 1).

(iii) Annotate the image with the related information, such as the pertinent components and dimensions (display with document camera 1). The students copy the material onto their own copies of the pages.

(iv) Move the page from (ii) and (iii) to document camera 2 (display with video projector 2).

(v) Write out the related notes and equations on the EPDDA (display with document camera 1).

Figure 4 shows typical images from the video projectors after the above steps were completed. Projection screen 2 displays the cross section of a manual transmission, while projection screen 1 shows the image of the related governing equations, which were written on the EPDDA.

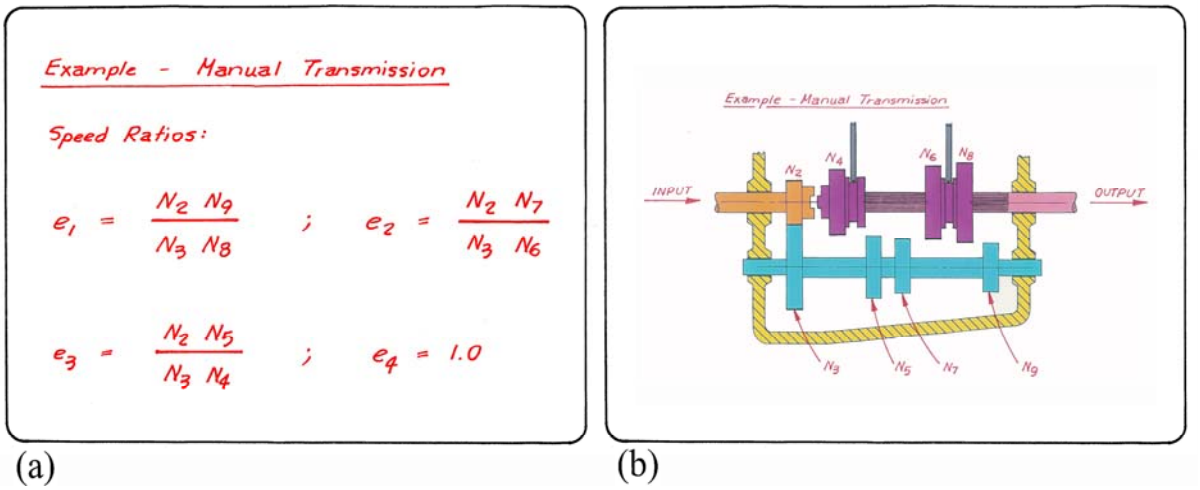


Figure 4 Typical Images from the Video Projectors (a) Image on Projection Screen 1, and (b) Image on Projection Screen 2.

The MEETS has the advantage to provide visual real time physical demonstrations of Engineering systems, and this can provide a positive environment for teaching using other interactive techniques (Bonwell and Eison (1991)). In the demonstration of a small mechanical system using document camera 1, (see item (i) above), it may be required to use the zoom control. In this instance, the instructor should use the small VGA monitor to ensure that the projected image remains in view. Figure 5 shows the demonstration of a small hand held gear train. Figure 5(a) illustrates an instructor demonstrating the gear train using the MEETS. The small VGA monitor shows the same image as that appears on projection screen 1 (see Figure 5(b)). The lecturer need not look over their shoulder to ensure the image is in view.

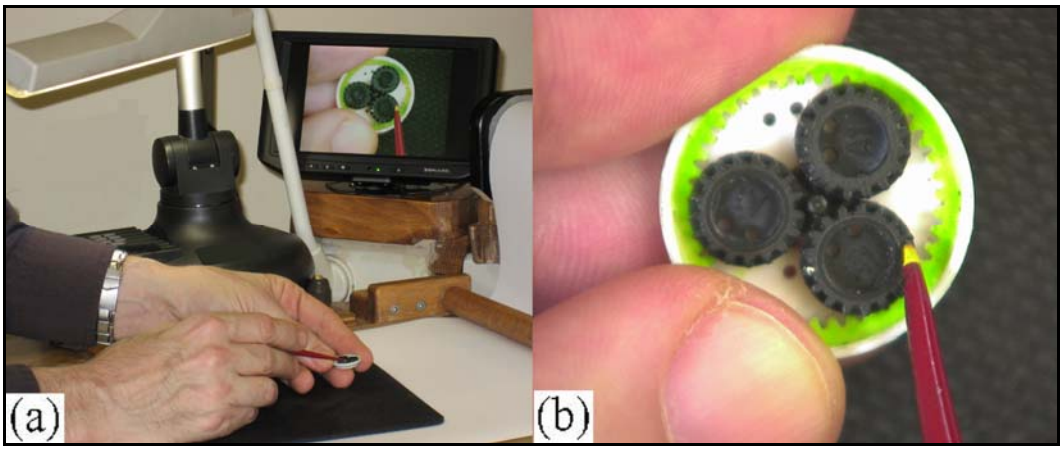


Figure 5 Demonstration of a Small Gear Train (a) Use of the EPDDA/MEETS, and (b) Image on Projection Screen 1.

The EPDDA/MEETS is ideally suited when a significant amount of graphical construction is required on a diagram. The instructor places the diagram in the viewable region. Projected images of the drafting devices and the hand of the instructor are included, which help to clearly show the method used for the construction. Figures 6(a), 6(b) and 6(c) show a sequence of three images for the drawing of a straight line with drafting devices. Figure 7(a) shows the initial image of a four-bar mechanism for which its instantaneous centres of velocity are to be determined, and the final result after drawing the lines is illustrated in Figure 7(b).

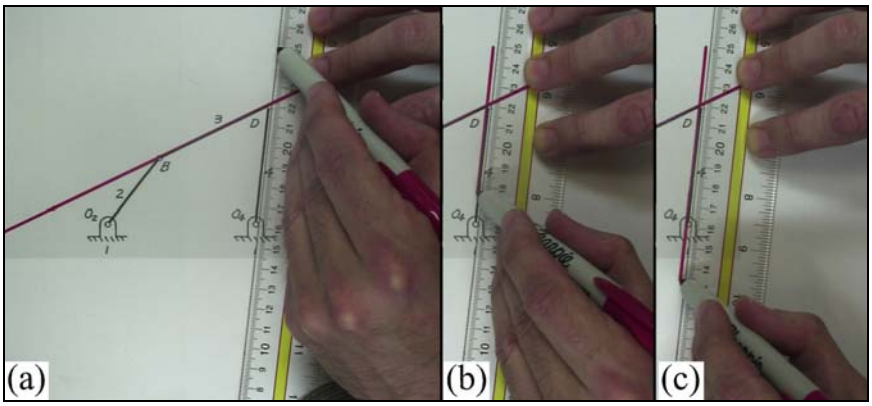


Figure 6 Projected Images for the Drawing of a Straight Line Using the EPDDA/MEETS (a) Before Drawing, (b) During Drawing, and (c) After Drawing.

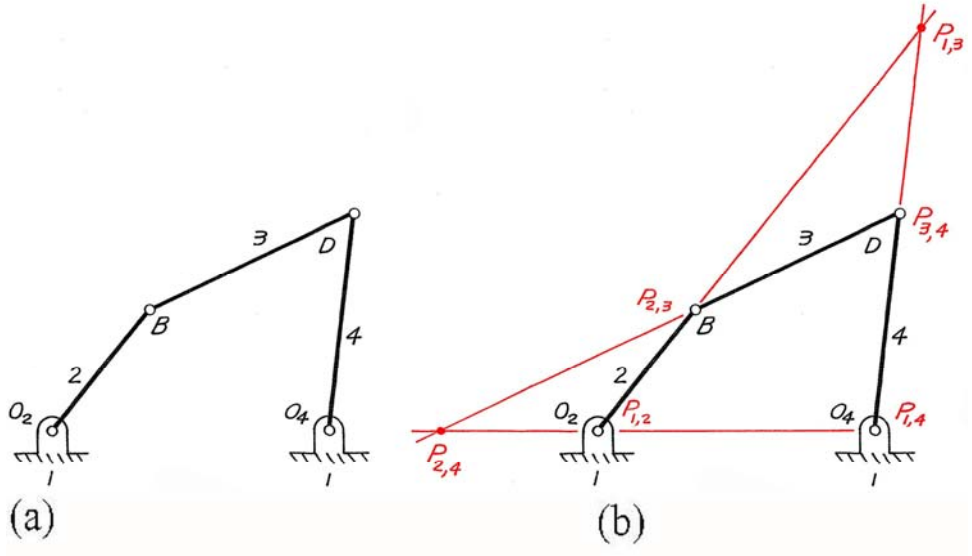


Figure 7 Instantaneous Centres of a Four-Bar Mechanism (a) Before Graphical Construction, and (b) After Graphical Construction.

When the MEETS is employed, the students are active participants rather than passive observers during lectures. They are required to copy the material which the instructor hand writes on the EPDDA. The students leave lectures with annotated and scaled diagrams, which are particularly important for graphical analyses.

4. COMPARISON OF THE MEETS WITH USING A TABLET PC

The MEETS retains the advantages of using a tablet PC over other technologies described in Section 1. The authors feel that the MEETS has the following advantages over using a tablet PC:

(i) The images of the hand of the instructor, along with the drafting devices, appear during writing and graphical constructions. The students therefore naturally follow the material being added, and can readily understand the graphical procedures employed. (see Figure 6) It also allows the instructor to point to the locations of interest. This is superior to having only inscriptions which just appear when using a tablet PC. For instance, Figures 8(a), 8(b) and 8(c) show a sequence of three images of the same graphical construction shown in Figure 6, but now using a tablet PC. Since images of the hand of the instructor are not seen, it would be far more challenging for the students to follow the method used for the graphical construction.

(ii) The MEETS allows the lecturer to demonstrate small physical mechanical components to large classes. (see Figure 5)

(iii) The MEETS allows lecturers to comfortably write lecture notes with the accustomed feel of ink markers and paper. The authors believe that a superior script can be created compared to using a tablet PC.

(iv) The MEETS eliminates any differences of the instantaneous positions of the tip of the marker and the script drawn on the paper. Small differences can occur when using a tablet PC, which may limit the complexity of the text and the diagrams which are drawn.

(v) Images of the written material remain projected a sufficient time to allow students to copy the material. The writing on the paper roll is slowly scrolled up on the EPDDA as the lecturer turns the hand wheel. This is distinct from using a tablet PC for which after finishing with a projected image, the lecturer could immediately advance to the next image, and not leave sufficient time for the students to copy.

5. CONCLUSIONS

The MEETS is used to teach both the undergraduate and graduate courses in Mechanical Engineering, and was employed recently for a large undergraduate course on mechanics with 195 students together in one classroom. The undergraduate students were asked to provide feedback of their experiences of taking lectures with the MEETS. The following comments were submitted: "The MEETS is an incredibly effective teaching tool for large classes."; "... (MEETS) allowed the instructor to show several live demonstrations which helped students attain a practical understanding of the presented material"; "... helped students to clearly follow the lecture material (by showing the actual hand of the instructor writing the material on paper)"; "... allows the instructor to point to important areas of interest on the displayed notes enhanced the quality of communication... "; "... made it easier for students to understand the instructor's writing, especially on annotated diagrams"; "... writing down the lecture notes forces the student to think about what they are writing and thus enriching the understanding of the presented material"; "... helps students actively pay attention in class"; "... having pictorial representations

of much of the class material available to print beforehand, and upon which annotations could be made and the bulk of the notes be taken, was a significant aid in the overall neatness of the lecture notes".

Because of the favorable feedback, the authors will continue using the MEETS. The technology used for MEETS is easily adaptable for the recording of lectures. Future plans include recording of the complete lectures with the MEETS projected images using current lecture capture technology and publishing to Engineering course websites.

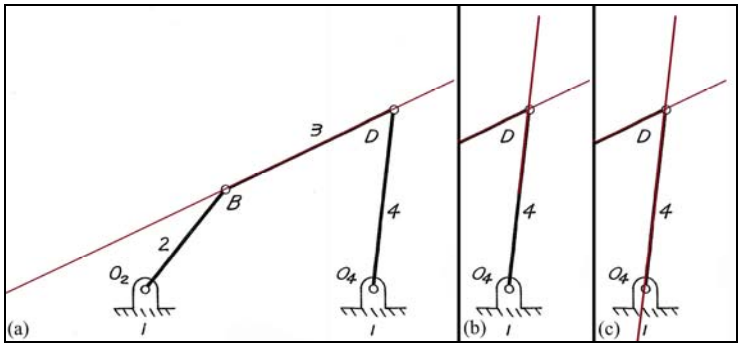


Figure 8 Projected Images for the Drawing of a Straight Line Using a Tablet PC (a) Before Drawing, (b) During Drawing, and (c) After Drawing.

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